LMS/RFS/S15528

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Fourth Five-Year Review Report for the Rocky Flats Site Jefferson County, Colorado

July 2017

U.S. DEPARTMENT OF ENERGY | Legacy Management

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July 2017

Approved by: Date:

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U.S. Department of Energy, Office of Legacy Management

Concurrence Letter Enclosed
U.S. Environmental Protection Agency

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Abbreviations

Am	americium
AOC	Area of Concern
AOI	analyte of interest
ARAR	applicable or relevant and appropriate requirement
CAD/ROD	Corrective Action Decision/Record of Decision
CCR	*Code of Colorado Regulations*
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminant of concern
COU	Central Operable Unit
CR	contact record
CRA	comprehensive risk assessment
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ETPTS	East Trenches Plume Treatment System
EU	exposure unit
EUR	Environmental Use Restriction
FR	*Federal Register*
FYR	five-year review
HQ	hazard quotient
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
IRIS	Integrated Risk Information System
LM	Office of Legacy Management
µg/L	micrograms per liter
m^3	cubic meters
M&M	monitoring and maintenance
MCL	maximum contaminant level
MDC	maximum detected concentration
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mrem/year	millirems per year

MSPTS	Mound Site Plume Treatment System
NCP	National Contingency Plan
NPL	National Priorities List
O&M	operation and maintenance
OLF	Original Landfill
OU	operable unit
OU3	Offsites Areas (operable unit)
pCi/g	picocuries per gram
PLF	Present Landfill
PLFTS	Present Landfill Treatment System
POC	point of compliance
POE	point of evaluation
POU	Peripheral Operable Unit
PQL	practical quantitation limit
PRG	preliminary remediation goal
Pu	plutonium
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RFLMA	Rocky Flats Legacy Management Agreement
RFP	Rocky Flats Plant
RFSC	Rocky Flats Stewardship Council
RI/FS	Remedial Investigation/Feasibility Study
RSL	regional screening level
SPPTS	Solar Ponds Plume Treatment System
TCE	trichloroethene
U	uranium
USFWS	U.S. Fish and Wildlife Service
UU/UE	unlimited use/unrestricted exposure
VOC	volatile organic compound
WRW	wildlife refuge worker
ZVI	zero-valent iron

Executive Summary

This fourth five-year review (FYR) report documents the evaluation of remedial actions implemented at the Central Operable Unit (COU) at the former Rocky Flats Plant (RFP) located near Denver, Colorado. The purpose of the FYR is to evaluate the implementation and performance of the remedy to determine whether the COU remedial actions remain protective of human health and the environment.

The location of the former RFP is approximately 16 miles northwest of Denver and 12 miles north of Golden in Colorado. The RFP was established in 1952 as part of the nuclear weapons complex to manufacture nuclear weapons components under the jurisdiction and control of the U.S. Department of Energy (DOE) and its predecessor agencies. Manufacturing activities, accidental industrial fires, spills, and support activities resulted in the release of hazardous constituents to air, soil, sediment, groundwater, and surface water at the RFP. Contaminants released to the environment include radionuclides such as plutonium, americium, and various uranium isotopes; organic solvents such as trichloroethene, tetrachloroethene, and carbon tetrachloride; metals such as chromium; and nitrates.

The RFP was listed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List (NPL) in 1989. In 1991, the RFP and surrounding lands were divided into 16 operable units (OUs) to facilitate investigation and cleanup. These OUs were ultimately consolidated into three OUs: the COU, the Peripheral OU (POU), and the Offsite Areas (OU3).

The COU contains the areas of the former RFP that required additional remedial/response actions. Following accelerated remedial actions, the COU was closed in 2005. The final remedy of environmental monitoring, continued operation and maintenance of engineered structures, and institutional and physical controls was selected for the COU in the 2006 Corrective Action Decision/Record of Decision (CAD/ROD). In 2007, the *Rocky Flats Legacy Management Agreement* (RFLMA) between DOE, the U.S. Environmental Protection Agency (EPA), and the Colorado Department of Public Health and Environment (CDPHE) was signed, which provides the implementing regulatory framework for the COU remedy.

The POU includes the generally unimpacted portions of the former RFP and surrounds the COU. The 2006 CAD/ROD contains the selected remedial action for the POU, which was no action. In May 2007, the POU was deleted from the NPL and the lands comprising the POU were transferred to the U.S. Fish and Wildlife Service for establishment as a National Wildlife Refuge.

OU3 consisted of lands outside the RFP boundary that were potentially impacted by historical operations. This OU was addressed under a separate no action CAD/ROD in June 1997 and the OU was deleted from the NPL in May 2007. A review of changes to toxicity factors conducted for this FYR confirmed that conditions in OU3 and the POU remain suitable for unlimited use and unrestricted exposure (UU/UE).

Because remaining contamination in the COU does not allow for UU/UE, CERCLA requires that a periodic review be conducted at least once every 5 years to determine whether the COU remedial actions remain protective of human health and the environment. This fourth FYR report covers remedy implementation at the COU for the period January 1, 2012, through

December 31, 2016. Table ES-1 presents the remedial action objectives (RAOs) established in the CAD/ROD, the remedy components that support the RAOs, and the current remedy status for the COU.

Protectiveness Determination

The COU remedy was reviewed according to the EPA *Comprehensive Five-Year Review Guidance*, which outlines a review process that includes community involvement, document and data review, site inspections, and a technical assessment of the protectiveness of a remedy. The three questions examined during the technical assessment are:

A. Is the remedy functioning as intended by the decision documents?

B. Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

C. Has any other information come to light that could call into question the protectiveness of the remedy?

No issues or recommendations for the COU were identified in the technical assessment.

Protectiveness Statement

The remedy at the COU is protective of human health and the environment.

Interim removal actions completed prior to the CAD/ROD included the removal of contaminated soils and sediments, decontamination and removal of equipment and buildings, construction of cover systems at the two landfills, and construction and operation of four groundwater treatment systems. A monitoring and maintenance plan is in place to assure the long-term integrity of the remedy. Routine inspections of remedy components ensure that maintenance and repairs are identified and implemented. Groundwater treatment systems continue to reduce contaminant load to surface water. Surface and groundwater monitoring provide assurance that water quality at the COU boundary is protective. Institutional controls are effective in preventing unacceptable exposures to residual contamination by prohibiting building construction, controlling intrusive activities, restricting use of groundwater and surface water, and protecting engineered remedy components. Physical controls are effective at controlling access to the COU.

Because the remedial actions at the COU are protective and the other OUs associated with the former RFP (POU and OU3) are suitable for UU/UE, the site is protective of human health and the environment.

Table ES-1. Remedial Action Objectives and Remedy Status

Remedial Action Objective	Remedy		Remedy Status
Groundwater			
1. Meet groundwater quality standards, which are the Colorado Water Quality Control Commission surface water standards, at groundwater AOC wells.	Institutional and physical controls: • Perimeter signage • Building construction prohibited • Excavation, drilling, digging restrictions • Drinking and agricultural surface water use prohibited • Unauthorized groundwater well drilling prohibited • Any activities that interfere with remedy actions prohibited except when in accordance with the RFLMA	• Groundwater monitoring at AOC wells • Groundwater monitoring at Sentinel wells • Monitoring and maintenance of groundwater treatment systems • Groundwater treatment prior to reaching surface water	Complete, in place, and protective in the long-term
2. Restore contaminated groundwater that discharges directly to surface water as base flow, and that is a significant source of surface water, to its beneficial use of surface water protection wherever practicable in a reasonable time frame. This is measured at groundwater Sentinel wells. Prevent significant risk of adverse ecological effects.			
3. Prevent domestic and irrigation use of groundwater contaminated at levels above MCLs.			
Surface Water			
1. Meet surface water quality standards, which are the Colorado Water Quality Control Commission surface water standards.	• Institutional controls listed above	• Surface water monitoring at POCs	Complete, in place, and protective in the long term
Soil			
1. Prevent migration of contaminants to groundwater that would result in exceedances of groundwater RAOs.	• Institutional controls listed above	• Groundwater monitoring at Sentinel wells • Groundwater treatment prior to reaching surface water	Complete, in place, and protective in the long term
2. Prevent migration of contaminants that would result in exceedances of surface water RAOs.		• Repair and maintenance of landfills covers, vegetation • Ongoing protection of remedy components	
3. (Part 1) Prevent exposures that result in an unacceptable risk to the wildlife refuge worker. The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at the site or multiple pathways of exposure (40 *Code of Federal Regulations* 300.430[e][2][i][A][2]). (Part 2) Prevent significant risk of adverse ecological effects.		• Repair and maintenance of landfill covers, vegetation • Ongoing protection of remedy components	

Abbreviations:
AOC = area of concern; ARARs = applicable or relevant and appropriate requirements; MCLs = maximum contaminant levels; POCs = points of compliance; RAOs = remedial action objectives; RFLMA = Rocky Flats Legacy Management Agreement

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Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Rocky Flats Site		
EPA ID: CO7890010526		
Region: 8	**State:** CO	**City/County:** Golden/Jefferson County

SITE STATUS	
NPL Status: Final	
Multiple OUs? Yes	**Has the site achieved construction completion?** Yes

REVIEW STATUS
Lead agency: Other Federal Agency **If "Other Federal Agency" was selected above, enter Agency name:** U.S. Department of Energy
Author name (Federal or State Project Manager): Scott Surovchak, Site Manager
Author affiliation: U.S. Department of Energy, Office of Legacy Management
Review period: June 10, 2016–June 20, 20
Date of site inspection: March 16, 2017
Type of review: Statutory
Review number: 4
Triggering action date: July 30, 2012
Due date *(five years after triggering action date)*: August 3, 2017
OUs Not Evaluated in This Five-Year Review:
For the POU and OU3, changes in risk assessment factors adopted since the initial UU/UE determinations were evaluated. Conditions in these OUs continue to allow for unlimited use and unrestricted exposure (UU/UE), and as a result, these OUs were not further evaluated in this FYR report.

1.0 Introduction

This fourth five-year review (FYR) report documents the evaluation of remedial actions implemented at the Central Operable Unit (COU) at the former Rocky Flats Plant (RFP), now the Rocky Flats site, located near Denver, Colorado. The purpose of the FYR is to evaluate the implementation and performance of the remedy to determine whether the COU remedial actions remain protective of human health and the environment. This FYR was conducted based on the requirements in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 121 and the National Contingency Plan (NCP). The FYR team consists of the U.S. Department of Energy (DOE) Office of Legacy Management (LM) as the lead agency, the U.S. Environmental Protection Agency (EPA) Region 8, and the Colorado Department of Public Health and Environment (CDPHE). This FYR covers remedy implementation at the COU for the period of January 2012 through December 2016. The cutoff date for inclusion of environmental monitoring data in this FYR is December 31, 2016 (unless otherwise noted).

The former RFP is located approximately 16 miles northwest of Denver and 12 miles north of Golden in Colorado (Figure 1 inset). The RFP was established in 1952 as part of the nuclear weapons complex to manufacture nuclear weapons components under the jurisdiction and control of DOE and its predecessor agencies. Manufacturing activities, accidental industrial fires and spills, and support activities resulted in the release of hazardous constituents to air, soil, sediment, groundwater, and surface water at the RFP. Contaminants released to the environment from activities at the RFP included radionuclides such as plutonium (Pu), americium (Am), and uranium (U); organic solvents such as trichloroethene (TCE), tetrachloroethene (PCE), and carbon tetrachloride; metals such as chromium; and nitrates.

2.0 Background

This section presents a summary of major actions taken at the former RFP. A chronology of site activities is presented in Appendix A, and additional information on the history of the RFP may be found in the *Third Five-Year Review Report for the Rocky Flats Site* (DOE, EPA, and CDPHE 2012).

Investigation and cleanup of the RFP began in the 1980s, while the plant was still operating. In 1989, the RFP was placed on the CERCLA National Priorities List (NPL). Soon thereafter, the RFP mission transitioned from nuclear weapons component production to cleanup and closure. Considerable remediation of the RFP took place during the late 1990s and early 2000s as interim measures/interim removal actions under the Rocky Flats Cleanup Agreement (RFCA). This agreement, signed by DOE, EPA, and CDPHE, adopted an accelerated action approach to cleanup. The interim measures/interim removal actions completed during accelerated cleanup from 1995 to 2005 included the construction and operation of four groundwater treatment systems, installation of engineered covers at the two landfills, decontamination and removal of RFP buildings and other structures, and removal and offsite disposal of contaminated soils and sediments. DOE completed cleanup and closure of the COU in 2005. A *RCRA Facility Investigation – Remedial Investigation/Corrective Measures Study – Feasibility Study for the Rocky Flats Environmental Technology Site* (RI/FS Report) (DOE 2006) was then completed that analyzed conditions within the COU following interim remedial actions. The primary contaminants, contaminated media, and waste remaining in the COU include:

- Wastes disposed in two closed landfills: the Present Landfill (PLF), and the Original Landfill (OLF).
- Some subsurface soils with residual volatile organic compounds (VOCs), metals, and radionuclides and areas where former building and infrastructure components, debris, and incinerator ash remain well below the surface with low levels of uranium, plutonium, and americium.
- Areas of groundwater contamination containing VOCs, nitrates, and uranium at levels above surface water quality standards.
- Areas of surface soil contaminated with low levels of plutonium and americium.
- Some subsurface areas with VOC contamination at levels that could lead to inhalation of unacceptable VOC concentrations by building occupants if buildings were constructed in these areas.

The RI/FS Report included a comprehensive risk assessment that calculated the risks posed by residual contaminants to the anticipated future land users and evaluated alternatives for the final remedial action. Based on the RI/FS Report, the former RFP boundaries were reconfigured into two operable units (OUs) in 2006:

- The COU, which included all areas that might require controls or further remedial action
- The Peripheral OU (POU), which comprised areas that would likely not require further action or controls.

The final remedy for each OU was selected in the 2006 Corrective Action Decision/Record of Decision (CAD/ROD). The selected remedy for the COU is institutional and physical controls with continued environmental monitoring and maintenance of engineered components. In 2007, the *Rocky Flats Legacy Management Agreement* (RFLMA) was signed by DOE, EPA, and CDPHE (DOE, EPA, and CDPHE 2007). This agreement superseded the RFCA and provided the implementing regulatory framework for the COU remedy. Attachment 2 to the RFLMA (Appendix B) specifies remedy performance standards, monitoring, inspection, and maintenance requirements, criteria for evaluating monitoring and inspection results, and reporting requirements.

The selected remedy for the POU in the 2006 CAD/ROD is no action, because this OU met the criteria for unlimited use/unrestricted exposure (UU/UE). The majority of land comprising the POU was transferred to the U.S. Fish and Wildlife Service (USFWS) in July 2007 for the purpose of establishing the Rocky Flats National Wildlife Refuge. An additional OU associated with the former RFP known as the Offsites Areas (OU3), was addressed in a separate no action CAD/ROD dated June 3, 1997 (DOE, EPA, and CDPHE 1997). This OU also met the conditions to allow for UU/UE. An evaluation of the POU and OU3 was completed during this FYR period to determine if changes to risk assessment factors (e.g., slope factors, reference doses) impact the UU/UE determinations for these OUs. This assessment concluded that the determinations of UU/UE at the POU and OU3 are still valid. A summary of this assessment is provided in Appendix C. Because the UU/UE determinations remain applicable at OU3 and the POU, these OUs were not further evaluated as part of this FYR.

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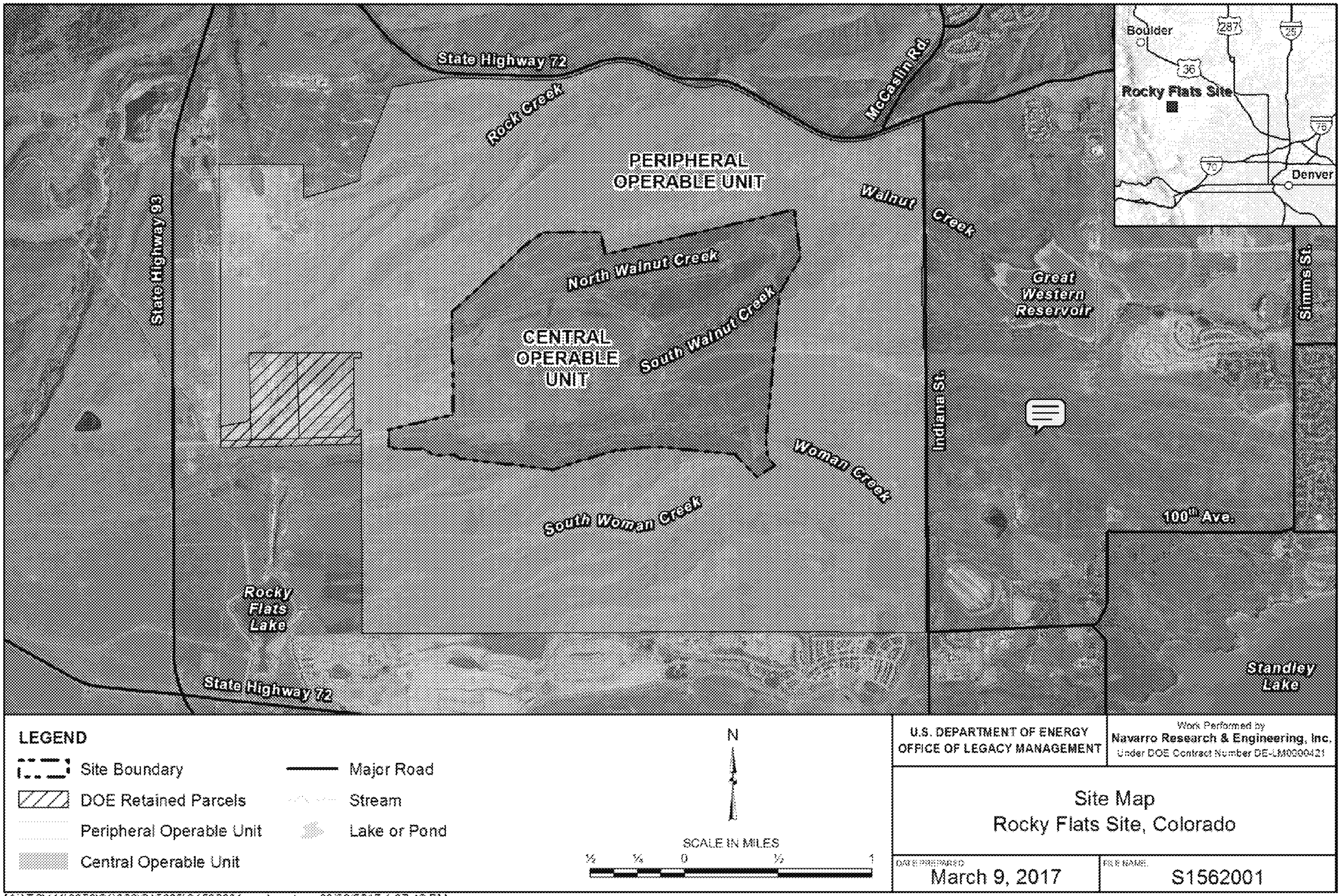

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Figure 1. Site Map

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3.0 Remedial Actions

3.1 Remedial Action Objectives

Remedial action objectives (RAOs) are the remediation goals a remedial action is designed to achieve. The RAOs for the COU were developed for groundwater, surface water, and soil and are presented in the CAD/ROD (DOE, EPA, and CDPHE 2006). The remedy components selected in the CAD/ROD that support the RAOs include institutional and physical controls, surface and groundwater monitoring, and maintenance of remedy engineered components (e.g., landfill covers, groundwater treatment systems). The RAOs and components of the remedy which are pertinent to achieving each RAO are shown in Table 1.

3.2 Remedy Selection

The selected remedy for the COU is environmental monitoring, continued operation and maintenance of engineered structures, and institutional and physical controls (DOE, EPA, and CDPHE 2006). Institutional controls prohibit unauthorized soil disturbance activities, activities that could damage the landfill covers or other remedy components, construction of buildings for human occupancy, and the non-remedy-related use of surface water or groundwater (Table 2). Physical controls consist of signs listing the institutional controls and DOE contact information posted at access points to the COU and signs prohibiting unauthorized access posted around the COU perimeter. Monitoring at the COU includes sampling and analysis of groundwater and surface water at specified locations and frequencies; inspection and maintenance of the OLF and PLF covers and groundwater treatment systems; and inspection of institutional and physical controls.

3.3 Remedy Implementation

3.3.1 Regulatory Framework

During this FYR period, the requirements of the remedy have been implemented in accordance with the RFLMA and through an Environmental Covenant incorporating the institutional controls for the COU granted by DOE to CDPHE. The RFLMA outlines the consultative process to be followed in implementing the agreement. The consultative process is initiated for all reportable conditions defined in RFLMA, other conditions not considered reportable, or at the request of RFLMA parties (DOE, EPA Region 8, and CDPHE). As stated in the RFLMA, "The objective of the consultation will be to determine a course of action to address the reportable condition and to ensure the remedy remains protective" (DOE, EPA, and CDPHE 2007). The outcome of consultation is typically documented in RFLMA contact records (CRs), which are available to the public on the LM website and part of the post-closure Administrative Record. Appendix D provides a list of RFLMA contact records documented since the inception of the RFLMA and a copy of the contact records referenced in this FYR report. Contact records from previous years may be obtained at https://www.lm.doe.gov/Rocky_Flats/ContactRecords.aspx.

Table 1. Remedial Action Objectives and Remedy Summary

Remedial Action Objective	Remedy
Groundwater	
1. Meet groundwater quality standards, which are the Colorado Water Quality Control Commission surface water standards, at groundwater area of concern wells.	• Groundwater monitoring at area of concern wells
2. Restore contaminated groundwater that discharges directly to surface water as base flow, and that is a significant source of surface water, to its beneficial use of surface water protection wherever practicable in a reasonable time frame. This is measured at groundwater Sentinel wells. Prevent significant risk of adverse ecological effects.	• Groundwater monitoring at Sentinel wells • Monitoring and maintenance of groundwater treatment systems • Groundwater treatment prior to reaching surface water
3. Prevent domestic and irrigation use of groundwater contaminated at levels above maximum contaminant levels.	• Institutional and Physical Controls, which prohibit building construction, control access to and intrusive activities within the COU, restrict use of groundwater and surface water, and protect engineered remedy components.
Surface Water	
1. Meet surface water quality standards, which are the Colorado Water Quality Control Commission surface water standards.	• Surface water monitoring at points of compliance
Soil	
1. Prevent migration of contaminants to groundwater that would result in exceedances of groundwater RAOs.	• Groundwater monitoring at Sentinel wells • Groundwater treatment prior to reaching surface water
2. Prevent migration of contaminants that would result in exceedances of surface water RAOs.	• Repair and maintenance of landfills covers, vegetation • Ongoing protection of remedy components
3. (Part 1) Prevent exposures that result in an unacceptable risk to the wildlife refuge worker. The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives when applicable or relevant and appropriate requirements are not available or are not sufficiently protective because of the presence of multiple contaminants at the site or multiple pathways of exposure (40 *Code of Federal Regulations* 300.430[e][2][i][A][2]). (Part 2) Prevent significant risk of adverse ecological effects.	• Repair and maintenance of landfill covers, vegetation • Ongoing protection of remedy components • Institutional and Physical Controls, which prohibit building construction, control access to and intrusive activities within the COU, restrict use of groundwater and surface water, and protect engineered remedy components. • Repair and maintenance of landfill covers, vegetation • Ongoing protection of remedy components

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Table 2. Rocky Flats Site Institutional Controls

Controls	Use Restrictions
1	The construction and use of buildings that will be occupied on a permanent or temporary basis (such as for residences or offices) is prohibited. The construction and use of storage sheds or other, non-occupied structures is permitted, consistent with the restrictions contained in controls 2 and 3 below, and provided such use does not impair any aspect of the response action at Rocky Flats.
	Objective: Prevent unacceptable exposures via the indoor air pathway. **Rationale:** The analysis of the indoor air pathway in the Comprehensive Risk Assessment indicated that subsurface volatile organic compounds were at levels in certain portions of the COU that could pose a risk of unacceptable exposure to the WRW if occupied structures were built in these areas.
2	Excavation, drilling, and other intrusive activities below a depth of three feet are prohibited, without prior regulatory review and approval pursuant to the Soil Disturbance Review Plan in RFLMA Attachment 2.
	Objective: Prevent unacceptable exposure to residual subsurface contamination. **Rationale:** Contaminated structures, such as building basements, exist in certain areas of the COU, and the Comprehensive Risk Assessment did not evaluate the risks posed by exposure to this residual contamination. Thus, this restriction eliminates the possibility of unacceptable exposures. Additionally, it prevents damage to subsurface engineered components of the remedy.
3	No grading, excavation, digging, tilling, or other disturbance of any kind of surface soils is permitted, except in accordance with an erosion control plan (including Surface Water Protection Plans submitted to EPA under the Clean Water Act) approved by CDPHE or EPA. Soil disturbance that will not restore the soil surface to preexisting grade or higher may not be performed without prior regulatory review and approval pursuant to the Soil Disturbance Review Plan in RFLMA Attachment 2.
	Objective: Prevent migration of residual surface soil contamination to surface water. **Rationale:** Certain surface soil contaminants, notably plutonium-239/240, were identified in the fate and transport evaluation in the Remedial Investigation as having complete pathways to surface water if disturbed. This restriction minimizes the possibility of such disturbance and resultant impacts to surface water. Restoring the soil surface to preexisting grade maintains the current depth to subsurface contamination or contaminated structures.
4	Surface water may not be used for drinking water or agricultural purposes.
	Objective: Prevent unacceptable exposure to local surface water contamination above the terminal ponds. **Rationale:** While the Comprehensive Risk Assessment did not evaluate the risks posed by the use of surface water for drinking or agricultural purposes, the nature and extent of contamination evaluation in the Remedial Investigation showed that certain contaminants were found at levels exceeding standards above the terminal ponds. This restriction reduces the possibility of unacceptable exposures to future users from this source.
5	The construction or operation of groundwater wells is prohibited, except for remedy-related purposes.
	Objective: Prevent unacceptable exposure to contaminated groundwater. **Rationale:** While the Comprehensive Risk Assessment did not evaluate the risks posed by the use of groundwater for drinking or agricultural purposes, the nature and extent of contamination evaluation in the Remedial Investigation identified areas in the COU where groundwater contaminants exceeded water quality standards or MCLs. This restriction reduces the possibility of unacceptable exposures to future users from this source. Additionally, it prevents the disruption of groundwater flow paths so as to avoid impacts on groundwater collection and treatment systems.
6	Digging, drilling, tilling, grading, excavation, construction of any sort (including construction of any structures, paths, trails or roads), and vehicular traffic are prohibited on the covers of the Present Landfill and the Original Landfill, except for authorized response actions.
	Objective: Ensure the continued proper functioning of the landfill covers. **Rationale:** This restriction helps ensure the integrity of the landfill covers.
7	Activities that may damage or impair the proper functioning of any engineered component of the response action, including but not limited to any treatment system, monitoring well, landfill cap, or surveyed benchmark, are prohibited. The preceding sentence shall not be construed to prohibit the modification, removal, replacement, or relocation of any engineered component of the response action in accordance with the action determinations in RFLMA Attachment 2.
	Objective: Ensure the continued proper functioning of engineered portions of the remedy. **Rationale:** This restriction helps ensure the integrity of other engineered components of the remedy, including monitoring and survey points.

Note: This table incorporates changes as a result of the 2011 CAD/ROD amendment (DOE, EPA, and CDPHE 2011).

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One Explanation of Significant Differences (ESD) was issued during this FYR period. This ESD is documented in CR 2016-02, which was written to satisfy both RFLMA and CERCLA reporting requirements. This ESD/CR documents the change in location of Mound plume groundwater treatment from the Mound Site Plume Treatment System (MSPTS) to the East Trenches Plume Treatment System (ETPTS). Previously, groundwater from the Mound plume and the East Trenches plume was treated by two separate treatment systems, located downgradient of each plume. The ESD/CR documented the reconfiguration of the MSPTS. This reconfiguration included the removal of the existing zero-valent iron (ZVI) treatment media and small air-stripper component from the MSPTS and rerouting the groundwater intercepted at the MSPTS to the ETPTS for treatment. The subsurface MSPTS collection system for groundwater impacted by the Mound plume was not altered.

3.3.2 Institutional and Physical Controls

The selected remedy in the CAD/ROD requires implementation of institutional and physical controls at the COU. The effectiveness of these controls is integral to the evaluation of groundwater, surface water, and soil RAOs (Table 1) and in determining protectiveness.

The institutional controls consist of a set of use restrictions that restrict or prohibit activities that may adversely impact the remedy and/or result in unacceptable exposures in the COU. These use restrictions were recorded in an Environmental Covenant between DOE and CDPHE in December 2006. The Covenant was modified in 2011 to clarify the use restriction language (DOE and CDPHE 2011); the modified use restrictions are presented in Table 2. The Environmental Covenant was in place throughout this entire FYR period (2012–2016); however, as recommended in the third FYR report, DOE has since replaced the Covenant with Environmental Use Restrictions (EURs) in accordance with *Colorado Revised Statutes* 25-15-318.5. The EURs supersede the Environmental Covenant and based on the current schedule, will be in place by April 2017. Unlike the Environmental Covenant, the EURs will allow CDPHE to enforce the institutional controls necessary to maintain the protectiveness of the remedy in the long term. EURs are binding on all current and future owners of the land and any persons possessing an interest in the land.

The physical controls implemented at the COU include signs located at access points and around the perimeter of the COU. DOE inspects the condition of signs and other physical controls on a quarterly basis.

DOE determines the effectiveness of the institutional controls described in the RFLMA and the Environmental Covenant by inspecting the COU at least annually for any evidence of violations of those controls (see Section 5.4). DOE also annually verifies that the Environmental Covenant remains in the Administrative Record and on file with the Jefferson County Planning and Zoning Department.

3.3.3 Remedy Monitoring and Maintenance

The selected remedy in the CAD/ROD also requires environmental monitoring of groundwater and surface water and continued operation and maintenance of engineered remedy components (landfill covers and groundwater treatment systems).

Groundwater monitoring is performed as required by the RFLMA. The groundwater monitoring network includes four types of monitoring wells: Area of Concern (AOC), Sentinel, Evaluation, and Resource Conservation and Recovery Act (RCRA). The AOC wells provide data directly relevant to groundwater RAO 1; the Sentinel wells provide data directly relevant to groundwater RAO 2 and soil RAO 1 (Table 1). AOC wells are located downgradient of contaminant plumes and are monitored to determine if groundwater contaminants are reaching surface water. Surface water monitoring location SW018 is monitored on the same routine schedule as the AOC wells to assess groundwater impacts to surface water from specific source areas in the COU. The locations of AOC wells and location SW018 are shown in Figure 2. Sentinel wells are located near downgradient edges of contaminant plumes and downgradient of the groundwater treatment systems. These wells are monitored to determine if concentrations of contaminants are increasing, indicating possible plume migration or treatment system issues. A discussion of AOC and Sentinel well data as they relate to RAOs is presented in Section 6.1.2. Evaluation wells are located within groundwater contaminant plumes and near plume source areas. Data from these wells support various objectives, such as providing input to groundwater modeling efforts, modification of groundwater monitoring and treatment requirements, or evaluation of changing contaminant conditions as indicated by downgradient AOC or Sentinel wells. RCRA wells are located at the PLF and OLF and are used to monitor groundwater conditions upgradient and downgradient of each landfill.

Surface water monitoring is performed as required by the RFLMA. The surface water monitoring network includes three types of locations: points of compliance (POCs), points of evaluation (POEs), and performance monitoring locations. The two POCs are located at the eastern boundary of the COU in Woman and Walnut Creeks and are monitored to determine water quality as it leaves the COU. Data collected at the POCs are evaluated against surface water quality standards and are directly relevant to the surface water RAO 1 in Table 1. A discussion of POC data as it relates to this RAO is presented in Section 6.1.3. The three POEs are located upstream of the POCs and provide an early indication of potential downstream impacts at the POCs. The POC and POE locations are shown in Figure 2. Data collected at performance monitoring locations are used to determine the short- and long-term effectiveness of specific remedies (e.g., groundwater treatment systems). A map showing the performance monitoring locations is presented in Appendix E.

The following specific remedy monitoring and maintenance activities are required in accordance with the CAD/ROD and/or RFLMA:

- **Residual subsurface contamination:** DOE must monitor the COU for significant erosion annually and following major precipitation events. DOE will evaluate whether the erosion is in proximity to the subsurface features shown on RFLMA Attachment 2, Figures 3 and 4 (Appendix B of this report). Monitoring will include visual observation (and measurements, if necessary) of precursor evidence of significant erosion (cracks, rills, slumping, subsidence, and sediment deposition).
- **Physical controls:** DOE must inspect the condition of signs and other physical controls on a quarterly basis.
- **Institutional controls:** DOE must determine the effectiveness of the institutional controls described in RFLMA Attachment 2 and in the Environmental Covenant (or restrictive notice) by inspecting the COU at least annually for any evidence of violations of those controls. DOE will also annually verify that the Environmental Covenant (or restrictive notice) remains in the Administrative Record and on file with the Jefferson County Planning and Zoning Department.

Figure 2. Central Operable Unit Features

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The engineered components of the remedy defined in the CAD/ROD consist of the PLF and OLF covers and the four groundwater treatment systems. Each engineered component has associated groundwater and surface water monitoring locations that support the evaluation of remedy performance. All remedy components are in place and operating in accordance with the RFLMA.

- **Landfills:** Inspection and maintenance requirements for the PLF and OLF remedies are provided in the approved monitoring and maintenance plans (DOE 2009; 2014a). At the OLF, the remedy involved the construction of a 2-foot-thick soil cover with a buttress at the toe of the landfill and the installation of perimeter drainage channels and cover diversion berms to control surface water run-on and runoff. The remedy at the PLF includes a RCRA-compliant cover consisting of a geosynthetic composite cover with a rock layer and surface water run-on and runoff controls. Performance of the landfill cover systems is evaluated in relation to soil RAOs 2 and 3 (Table 1) and is discussed in Sections 6.1.4.1 and 6.1.4.2.
- **Groundwater treatment systems:** At a minimum, each system is monitored for untreated influent, treated effluent, and impacts to surface water downstream of the effluent discharge point. The remedy in the CAD/ROD incorporated the four passive groundwater treatment systems in place when the COU closed in 2005: the Present Landfill Treatment System (PLFTS), the Solar Ponds Plume Treatment System (SPPTS), the Mound Site Plume Treatment System (MSPTS), and the East Trenches Plume Treatment System (ETPTS). Optimization and reconfiguration of three of these treatment systems (SPPTS, MSPTS, and ETPTS) has taken place during this FYR period and is discussed further in Section 6.1.4.3. Performance of these systems is evaluated in relation to groundwater RAO 2 and soil RAO 1 (Table 1) and is discussed in Sections 6.1.4.1 (PLFTS) and 6.1.4.3 (SPPTS, MSPTS, and ETPTS).

4.0 Progress Since the Last Five-Year Review

The protectiveness statement from the third FYR report is as follows (DOE, EPA, and CDPHE 2012):

The remedy for the COU is protective of human health and the environment because surface water concentrations are meeting standards at points of compliance, and monitoring and maintenance plans and institutional controls are working to prevent unacceptable exposure to site contaminants.

The third FYR report identified four issues to be addressed in the next FYR period. Table 3 presents each issue and a summary of the status at the end of this FYR period. Three of the identified issues concerned reportable conditions for radionuclides at surface water POE monitoring locations. Additional detail regarding these POE reportable conditions is presented in Appendix E.

Based on the results of this fourth FYR, all issues from the third FYR have been satisfactorily resolved.

Table 3. Status of the Third FYR Report Recommendations

Issue	Follow-Up and Expected Completion Date	Status	Does Issue Affect Protectiveness?
Surface water point of evaluation (POE) GS10 uranium concentration periodically exceeded the RFLMA standard during the third FYR period and exceeds the standard at the end of the third review period. POEs are located upstream of surface water POCs at the edge of the former Industrial Area to provide early indication of potential contaminant migration.	The RFLMA consultative process is effective in determining whether, and to what extent, any mitigating action may be recommended and in establishing the schedule to complete actions. Uranium levels at GS10 are linked to seasonal low-flow conditions and the influence of predominantly natural uranium in groundwater that contributes to base flow at GS10. Continue to monitor in accordance with RFLMA requirements. Complete work in accordance with the CDPHE- and EPA-approved evaluation plan.	Complete. The RFLMA standard for U has been exceeded at GS10 intermittently during this FYR period (see Appendix E). Figure E-7 illustrates the 12-month rolling averages for U at GS10. The exceedances and subsequent reportable conditions for U led to an extensive evaluation of the Walnut Creek drainage system (Wright Water Engineers 2015). This evaluation identified natural processes that may be contributing to U increases in surface water, including precipitation events in 2013 and 2015 (see Section 6.1.3). At the end of this fourth FYR period, the 12-month rolling average for U at GS10 does not exceed the RFLMA standard.	No. Consultation with the RFLMA parties on the reportable conditions for U at GS10 resulted in an evaluation plan for addressing the condition (CR 2011-04, CR 2011-05) to ensure the remedy remains protective.
Surface water POE GS10 americium concentration began to exceed the RFLMA standard in 2011 and exceeded the standard at the end of the third FYR period.	The RFLMA consultative process is effective in determining whether, and to what extent, any mitigating action may be recommended and in establishing the schedule to complete actions. Americium levels at GS10 may be linked to colloidal transport mechanisms or surface soil and sediment erosion mechanisms. Soil erosion does not appear to be a primary factor, since erosion is usually associated with heavy precipitation events and high-flow conditions. The elevated americium levels have occurred generally during low-flow conditions indicating colloidal transport at GS10. Continue to monitor in accordance with RFLMA requirements. Complete work in accordance with the CDPHE- and EPA-approved evaluation plan.	Complete. The RFLMA standards for Pu and Am have been exceeded at GS10 intermittently during this FYR period (see Appendix E). Figure E-8 illustrates the Pu and Am 12-month rolling averages at GS10. Evaluation of these reportable conditions did not yield a definitive cause for the exceedances. Monitoring locations downstream at GS08 and WALPOC did not exceed the standards during this time period. Plutonium and americium concentrations fell below RFLMA standards in 2014, and routine monitoring at GS10 recommenced. At the end of this fourth FYR period, the 12-month rolling averages for Am and Pu at GS10 do not exceed the RFLMA standard.	No. Consultation with the RFLMA parties on the reportable conditions for Am and Pu at GS10 resulted in an evaluation plan for addressing the condition (CR 2011-08) to ensure the remedy remains protective.

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Table 3. Status of the Third FYR Report Recommendations (continued)

Issue	Follow-Up and Expected Completion Date	Status	Does Issue Affect Protectiveness?
Surface water POE SW027 plutonium concentration exceeded the RFLMA standard in 2010 during a high precipitation event. The standard was no longer exceeded at the end of the third FYR period.	The RFLMA consultative process is effective in determining whether, and to what extent, any mitigating action may be recommended and in establishing the schedule to complete actions. After mitigating actions to improve erosion controls in the drainage were completed in 2010, only very small volumes of infrequent, short-term, intermittent flows occurred at SW027. As a result, no samples were obtained for over a year. Because the RFLMA standard is based on 12- month rolling average of the results, and there were no sample results for averaging, the standard was no longer exceeded at the end of the third FYR review period (2012). Samples will be obtained when there is sufficient flow to evaluate the effectiveness of the mitigating measures. Continue to monitor in accordance with RFLMA requirements.	Complete. The RFLMA standards for Pu and Am were exceeded at SW027 intermittently beginning in 2010 through the end of this FYR period (see Appendix E). Figure E-13 illustrates the Am and Pu 12-month rolling averages at SW027. The exceedances coincide with periods of increased runoff resulting from heavy precipitation. Evaluation of these reportable conditions suggests that Pu and Am move with particulates (DOE 2013) and may be a result of soil erosion. Mitigation measures to control erosion originating from the contaminant source at the 903 Pad/Lip Area were completed in 2010, 2011, and 2015 following each reportable occurrence. Evaluation of upstream and downstream data does not indicate an unknown source of contamination. There have been no exceedances of Pu or Am at WOMPOC, located downstream of SW027, during this fourth FYR period.	No. Consultation with the RFLMA parties on the reportable conditions for Am and Pu at SW027 resulted in an evaluation plan for addressing the condition (CR 2015-05) to ensure the remedy remains protective.
Institutional controls might not be easily enforceable against a utility easement holder who is not a party to the Environmental Covenant. While this is not a near-term issue (because the Office of Legacy Management maintains a good working relationship with the current easement holder), the lack of enforceability could become an issue in the future if LM and the easement holder (or any successor) do not maintain routine contact.	Replace the Environmental Covenant with restrictive notice under Colorado law, as provided for in the 2011 CAD/ROD amendment. While an environmental covenant might not be directly enforceable against a prior holder of an interest in land who is not a party to the covenant, a restrictive notice is enforceable by CDPHE against any person in violation of the institutional controls. DOE and CDPHE will consult with the goal to replace the Environmental Covenant with a restrictive notice by end of 2012.	Complete. The Environmental Use Restrictions (EURs) are scheduled to become effective in April 2017. The EURs supersede the Environmental Covenant adopted in 2006 and modified in 2011.	No. There have been no incidences involving current easement holders that call into question the effectiveness of institutional or physical controls. However, the establishment of EURs provides a means of enforcing these controls.

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5.0 Five-Year Review Process

5.1 Community Notification and Involvement

Notification of commencement of the fourth FYR was distributed to Rocky Flats site stakeholders via email and posted to the LM website on June 10, 2016. This notice included an overview of the FYR process, web links to the 2012 FYR report, LM contact information, and the address to submit questions or input related to the FYR.

The FYR team gave a public presentation on the fourth FYR at the June 6, 2016, Rocky Flats Stewardship Council (RFSC) meeting, which was open to the public. The RFSC serves as a quarterly forum to promote community involvement with the Rocky Flats site, including the FYR. Other public communication tools include the LM website and emails to stakeholders. Notification of the RFSC FYR presentation was provided directly to stakeholders via email and was posted on the LM and RFSC public websites prior to the meeting. The FYR presentation included an overview of the review process including community involvement and a question and answer period.

In response to email questions from stakeholders regarding public review of the FYR report, an update to the initial June 2016 notification was provided on November 15, 2016. This notice was distributed to Rocky Flats stakeholders via email and posted to the LM website. The update clarified that while a formal public review and comment period for the FYR report was not included in the CERCLA FYR process, the public was invited to submit questions and input by way of the communication tools provided in the notice. The update contained several web links to EPA guidance on community participation in the FYR process and general information on FYRs. In order to meet the FYR report schedule, the update requested that public input be provided no later than December 31, 2016.

EPA guidance includes consideration of whether interviews with local residents or other stakeholders are needed to identify issues that might be included in the FYR. The RFLMA parties keep the public and local community governments informed by making all RFLMA required reports and contact records available on the LM public website, making quarterly presentations at RFSC meetings, holding periodic technical meetings with local community governments, and providing formal public review and comment periods as required for proposed RFLMA modifications and CAD/ROD amendments. Based on these continual public participation activities and the steps taken to inform the public about this FYR process, DOE, EPA, and CDPHE concluded that interviews were not needed.

Written FYR input from stakeholders was received during the requested submittal period in the form of four formal letters. In addition, verbal input and questions from stakeholders were offered at RFSC and other stakeholder meetings. Stakeholder input was consolidated by topic where possible, to remain consistent with past practices. A summary of this input and the responses provided by the FYR team are presented in Appendix I.

5.2 Document Review

Documents reviewed for this FYR are listed in Appendix F. Where appropriate, references to documents where additional information or data may be found are cited throughout this report.

5.3 Data Review

The CAD/ROD and RFLMA require routine monitoring of surface water and groundwater. The data from these monitoring activities are relevant in determining if the RAOs are met. The COU quarterly and annual reports contain monitoring and maintenance data pertaining to surface water and groundwater, the OLF and PLF, and the groundwater treatment systems. This information was used to assess the performance of the remedy over this FYR period.

Attachment 2 of the RFLMA specifies the remedy performance standards and requirements for the selected remedy (Appendix B). These standards and requirements are numerical values or narrative descriptions of conditions or restrictions, designed to protect existing or potential uses, against which remedy performance can be measured. These standards and requirements are derived from state surface water standards and from requirements established in the final CAD/ROD (e.g., landfill inspections). The remedy performance standards for surface water in the COU are found in Table 1 of Attachment 2 to the RFLMA. Because groundwater flows into surface water prior to exiting the COU, the groundwater use classification at the COU is surface water protection. Thus, the numeric values for measuring potential effects of contaminated groundwater on surface water quality are also the surface water standards in Table 1 of Attachment 2 to the RFLMA. Surface water and groundwater monitoring data are evaluated annually (at a minimum) by comparing results to the Table 1 standards and conducting RFLMA-required statistical analyses. The results of these evaluations are presented in the COU quarterly and annual reports required by the RFLMA and available on the LM website.

If reportable conditions defined in RFLMA are identified as a result of data evaluation, the RFLMA parties (DOE, EPA, and CDPHE) consult and develop a plan for evaluating and addressing the condition. During this fourth FYR period, reportable conditions were documented at the OLF (CR 2013-02), AOC well 10304 (CR 2015-10), POE SW027 (CR 2015-05), and WALPOC (CRs 2014-05, 2015-01, 2016-01, 2017-02). These reportable conditions are discussed in Section 6.1 and Appendix E.

5.4 Site Inspections

EPA guidance indicates that the FYR should include a recent site inspection to visually confirm and document the conditions of the remedy, the site, and the surrounding area (EPA 2001). The CAD/ROD and RFLMA also require an annual inspection of the COU, in addition to more frequent routine and weather-related inspections of remedy components at the PLF and OLF. During this FYR period, all routine inspections, and several weather-related inspections, were conducted and reported in accordance with RFLMA requirements.

This section summarizes the results of the annual inspections of the COU conducted during this FYR period; the results of routine and weather-related inspections at the PLF and OLF are summarized in Sections 6.1.4.1 and 6.1.4.2, respectively. Inspection results, including completed inspection forms, may be found in the COU quarterly and annual reports.

Annual inspections of the COU were conducted in March or April during this FYR period. The most recent COU inspection was conducted on March 16, 2017. Representatives from DOE, EPA, and CDPHE participate in the annual inspections. Appendix G contains the inspection checklist and maps of the most recent inspection.

The following are assessed during each annual COU inspection:

- Evidence of significant erosion in the COU and evaluation of the proximity of any significant erosion to subsurface features left in place at closure. This monitoring includes visual observation for precursors of significant erosion (e.g., cracks, rills, slumping, subsidence, sediment deposition).
- The effectiveness of institutional controls, as determined by any evidence of violation.
- Evidence of adverse biological conditions, such as unexpected morbidity or mortality, observed during the inspection and monitoring activities.

Quarterly and weather-related inspections for erosion in areas where building features remain in the subsurface were completed as required during this FYR period. Evidence of subsidence near the locations of former buildings 771, 881, and 991 was noted in the 2015 annual site inspection (DOE 2016). The openings ranged from 1 to 8 feet in width and 1 to 5 feet in depth. These areas were filled and graded shortly after discovery. In 2016, additional settling was noted in the former building 881 area where the subsidence had been filled the previous year. In response, this area was filled and graded.

No evidence of violations of institutional controls or physical controls was observed in any of the annual inspections. In conjunction with each annual inspection, the presence of the Environmental Covenant in the Administrative Record and Jefferson County records was verified. The most recent verification of the Environmental Covenant was completed on March 16, 2017. The physical controls required by the remedy (i.e., signs at the COU boundary and access points) were inspected four times a year (i.e., quarterly) throughout this FYR period. A few signs were added or replaced, and faded stickers were replaced, as needed. The signs continue to function as designed.

No adverse biological conditions were noted during any of the annual COU inspections during this FYR period.

6.0 Technical Assessment

This section documents the technical assessment of the performance of the remedy. This assessment includes:

- Consideration of monitoring and maintenance information reported in the COU quarterly and annual reports.
- Information on post-remedy decision making documented in RFLMA contact records and amendments or modifications to remedy requirements.
- Evaluation of remedy performance against RAOs.
- Changes to remedy applicable or relevant and appropriate requirements (ARARs).
- Changes to toxicity factors, exposure parameters, or assumptions that might affect the level of risk posed by residual contamination.
- Any new information that may call into question the protectiveness of the remedy.

6.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

Based on this FYR evaluation, the remedy is functioning as intended by the CAD/ROD (DOE, EPA, and CDPHE 2006):

- Institutional controls are in place and effective in meeting the objectives presented in Table 2. Physical controls are in place and effective.
- Required groundwater and surface water monitoring is ongoing and supports achievement of RAOs in the long term.
- Operation and maintenance (O&M) of remedy components at the OLF, PLF, and groundwater treatment systems is ongoing and supports achievement of RAOs in the long term.

6.1.1 Institutional and Physical Controls

The institutional and physical controls required by the remedy are in place and effective in preventing unacceptable exposures. The effectiveness of institutional controls is determined by annually inspecting the COU for evidence of violations. Less-formal inspections and observations are performed throughout the year by site staff as they perform regular monitoring and maintenance activities. An annual verification that the Environmental Covenant is located in the Administrative Record and in Jefferson County records is also required. Annual inspections of the COU were completed in accordance with RFLMA. No evidence of institutional control violations was discovered. The presence of the Environmental Covenant in the Administrative Record and Jefferson County records was verified on March 16, 2017.

6.1.2 Groundwater Monitoring

The groundwater monitoring network in the COU consists of four types of wells (AOC, Sentinel, Evaluation, and RCRA) and one surface water location (SW018). Data from groundwater monitoring at AOC and Sentinel wells and location SW018 are directly relevant to assessing remedy performance in relation to groundwater RAOs 1 and 2 and Soil RAO 1. Remedy performance for the AOC and Sentinel wells and SW018 is discussed in this section. Data from Evaluation wells are discussed in Appendix E; data from RCRA wells are discussed in Sections 6.1.4.1 and 6.1.4.2.

6.1.2.1 AOC Wells

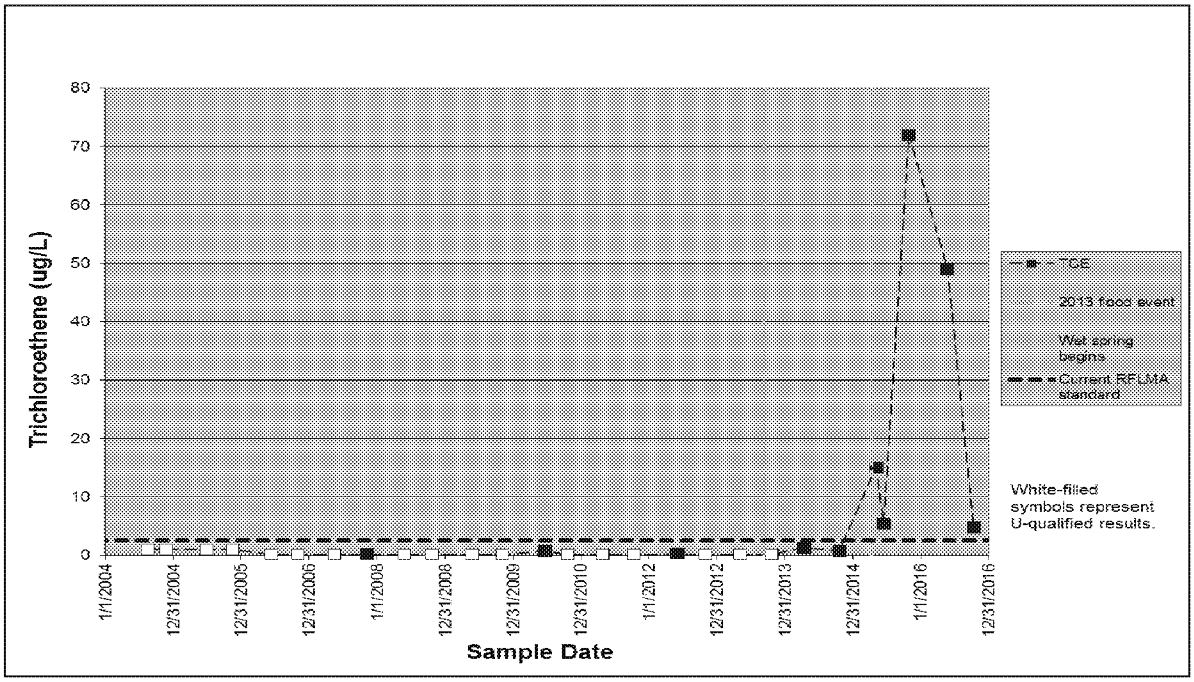
The existing AOC well network consists of nine wells from which routine RFLMA monitoring samples are collected twice a year (i.e., semiannually); surface water samples from location SW018 are also collected semiannually. Remedy performance is measured at AOC wells and SW018 by an evaluation of the two most recent routine monitoring results as compared to RFLMA standards. The RFLMA Attachment 2 decision logic flowchart Figure 7, "Area of Concern Wells and SW018" (Appendix B), is relevant to these evaluations. If the results for an individual constituent in the two most recent routine samples are greater than its respective RFLMA standard, a reportable condition exists and consultation with EPA and CDPHE is required. There was one reportable condition at an AOC well during this FYR period.

Trichloroethene (TCE) exceeded the RFLMA standard in the two sample results from AOC well 10304 in 2015 (CR 2015-10). The RFLMA standard for TCE is 2.5 micrograms per liter (µg/L), and the results were 15 and 72 µg/L in the 2015 groundwater samples. AOC well 10304 was installed in 2004 to evaluate groundwater quality adjacent to Woman Creek, downgradient of the contaminant plume caused by the 903 Pad and Ryan's Pit (Figure 2). As evidenced in Figure 3, TCE was detected in this well previously; however, this is the first reportable condition at this well.

As required by the RFLMA, DOE consulted with EPA and CDPHE and developed a plan for addressing the reportable condition. The plan included the collection of surface water samples from Woman Creek downgradient of well 10304, to assess any potential impacts to surface water quality. A surface water sample from downgradient Woman Creek location SW10200 (Figure 2) was collected in December 2015; TCE was not detected in this sample. Additional samples from this surface water location were collected concurrent with well 10304 semiannual sampling in 2016; TCE was not detected in these samples. TCE was detected in the two 2016 groundwater samples at 49 and 4.7 µg/L (Figure 3), levels which are both above the RFLMA TCE standard.

Increased concentrations of TCE in groundwater discharging to Woman Creek in this area under conditions of higher-than-normal precipitation were predicted when the COU was closed (Kaiser-Hill 2005). The potential for increased VOC concentrations during wet conditions is described in the *Final Interim Measure/Interim Remedial Action for Groundwater at the Rocky Flats Environmental Technology Site* (Kaiser-Hill 2005) and the *Fate and Transport Modeling of VOCs at the Rocky Flats Environmental Technology Site* (Kaiser-Hill 2004). Given that the fall of 2013 and spring of 2015 were exceptionally wet, the TCE results reported for AOC well 10304 are not unexpected. As conditions become drier, VOC concentrations in groundwater should decrease, as is the observed trend at well 10304 (Figure 3).

TCE concentrations in AOC well 10304 are currently in decline, however, as of the end of this FYR period, the most recent semiannual data show a TCE concentration above the RFLMA standard. The reportable condition still exists, and therefore, groundwater RAO 1 is not currently met at all AOC wells (Table 4). As stated in the CAD/ROD, the RAOs for each medium are interdependent and were developed based on this premise (DOE, EPA, and CDPHE 2006). Because of the hydrologic connection of groundwater with surface water within the COU, it is therefore appropriate to assess surface water quality in combination with groundwater results in evaluating overall remedy protectiveness. The remedy remains protective in the long-term because (1) the 2016 data suggest a decreasing trend in TCE concentration in this well, suggesting a short-term event that is consistent with predictions made prior to closure, and (2) the reportable condition has not impacted downstream surface water quality, as TCE was not detected in surface water samples from Woman Creek collected downgradient of the well.



Note:
A temporary modification to the TCE standard was in effect until the end of 2009. For simplicity, this standard is not shown on the figure above; the current TCE water quality standard of 2.5 µg/L is presented.

Figure 3. TCE Concentrations at AOC Well 10304 (2004–2016)

6.1.2.2 Sentinel Wells

Sentinel wells are typically located near downgradient edges of contaminant plumes, in drainages, at groundwater treatment systems, and along contaminant pathways to surface water (Figure 4). These wells are monitored to determine whether concentrations of contaminants indicate plume migration or treatment system problems that may result in impacts to surface water quality. The existing Sentinel well network consists of 27 wells from which routine monitoring samples are collected semiannually. The RFLMA Attachment 2 decision logic flowchart Figure 8, "Sentinel Wells" (Appendix B), is relevant to these data. Groundwater quality in Sentinel wells at the end of this FYR period was generally consistent with conditions at the time of closure. Groundwater does not meet RFLMA standards for some VOCs, uranium, or nitrate at many Sentinel well locations. While there are no indications of significant plume migration that impact the continued protectiveness of the remedy, groundwater RAO 2 and soil RAO 1 are not currently met at all Sentinel wells (Table 4). The CAD/ROD stated that no additional removal, containment, or treatment actions could be reasonably taken to address these RAOs at the time and recognized that the remedial actions undertaken as a part of closure of the COU were "not expected to eliminate groundwater contamination in the short term, but are expected to have a positive long-term impact on groundwater and surface water quality" (DOE, EPA, CDPHE 2006). These statements remain valid for this FYR period, and therefore, continued monitoring of the Sentinel wells is necessary.

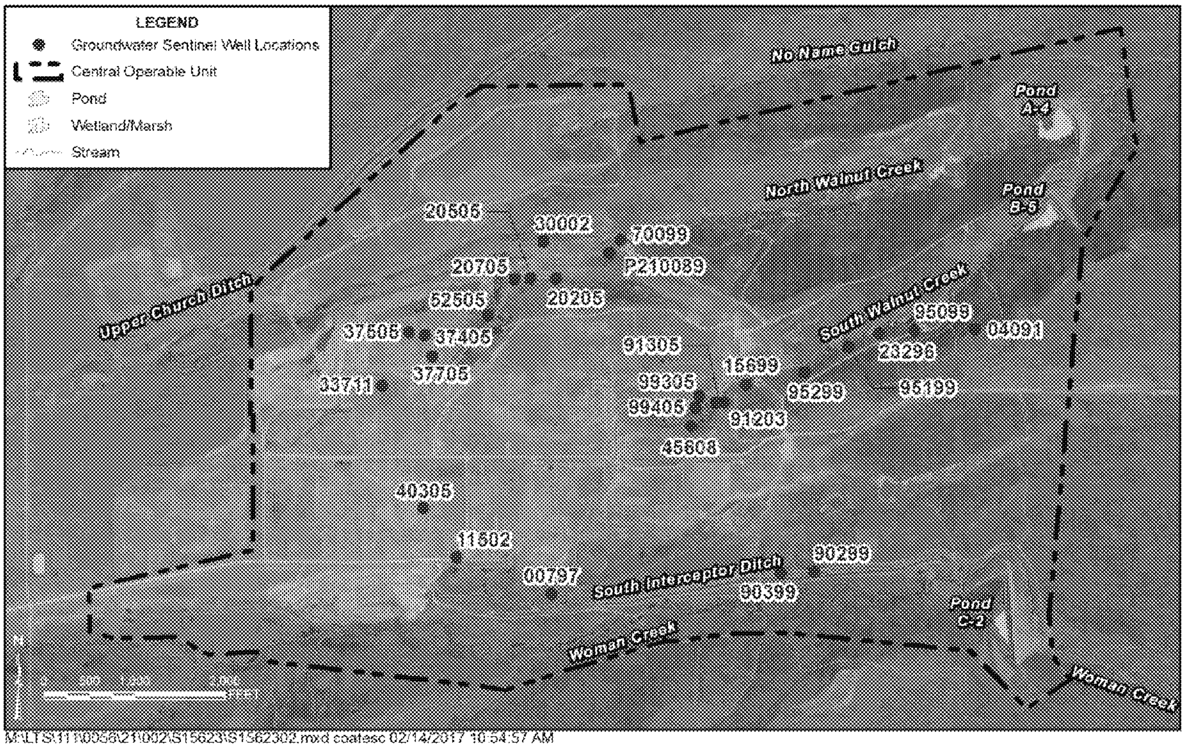


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Figure 4. Sentinel Well Locations

6.1.3 Surface Water Monitoring

The surface water monitoring network in the COU consists of three types of locations: POCs, POEs, and performance monitoring locations. Data from surface water monitoring at POCs are directly relevant to assessing remedy performance in relation to surface water RAO 1 and are discussed in this section. Data from surface water monitoring at POEs and performance monitoring locations are discussed in Appendix E.

6.1.3.1 Points of Compliance

At the beginning of this FYR period, there were two POC locations outside the COU boundary adjacent to Indiana Street (locations GS01 and GS03). In January 2014, following RFLMA modification and in consultation with EPA and CDPHE, the POCs were moved upstream to the WOMPOC and WALPOC locations just inside the eastern boundary of the COU (see CR 2014-02 and Figure 2). The WOMPOC (within Woman Creek) and WALPOC (within Walnut Creek) surface water POCs are used to measure remedy performance against applicable RFLMA surface water standards at the COU boundary prior to surface water leaving the COU. Remedy performance at the POCs is measured through a comparison of the volume-weighted 12-month rolling average of the composite sample results collected at each POC to the applicable RFLMA surface water quality standards. The volume-weighted 30-day average of these results is also evaluated. The RFLMA Attachment 2 decision logic flowchart Figure 5, "Points of Compliance" (Appendix B), is relevant to these evaluations. An exceedance of either calculated average is a reportable condition under RFLMA that requires consultation with EPA and CDPHE.

Table 4. Fourth FYR RAO Status

RAO	Remedy	FYR Status
Groundwater		
1. Meet groundwater quality standards, which are the Colorado Water Quality Control Commission surface water standards, at groundwater AOC wells.	• Groundwater monitoring at AOC wells	A reportable condition for TCE in AOC well 10304 occurred in 2015 (Section 6.1.2). Consultation with the RFLMA parties (CR 2015-10) resulted in a plan to evaluate the condition to ensure the remedy remains protective. At the end of this FYR period, the most recent semiannual data show a TCE concentration above the RFLMA standard at AOC well 10304. The remedy remains protective because (1) the 2016 data indicate a decreasing trend in TCE concentration in this well, suggesting a short-term event and (2) the reportable condition did not impact downstream surface water quality, as TCE was not detected downgradient of the well in Woman Creek.
2. Restore contaminated groundwater that discharges directly to surface water as base flow, and that is a significant source of surface water, to its beneficial use of surface water protection wherever practicable in a reasonable time frame. This is measured at groundwater Sentinel wells. Prevent significant risk of adverse ecological effects.	• Groundwater monitoring at Sentinel wells • Monitoring and maintenance of groundwater treatment systems • Groundwater treatment prior to reaching surface water	Sentinel well data exceeded applicable RFLMA standards for some VOCs, nitrate, or uranium. Optimization and technical improvement opportunities at the SPPTS, MSPTS, and ETPTS were identified and implemented during this FYR period through the RFLMA consultative process (CRs 2012-02, 2014-01, 2014-04, 2014-08, 2015-04, 2015-08, 2015-09, and 2016-02). Optimization of the systems has resulted in reductions of nitrate and VOC concentrations in treated groundwater (see Section 6.1.4.3). Evaluation of groundwater treatment system monitoring and operation is summarized in Appendix E. The ecological risk assessment conclusions remain valid and indicate that residual contamination in the COU does not present a significant risk of adverse ecological effects. No evidence of adverse biological conditions (e.g., unexpected mortality or morbidity) was observed during this FYR period (2012–2016).
3. Prevent domestic and irrigation use of groundwater contaminated at levels above maximum contaminant levels.	Institutional controls: • Drinking and agricultural surface water use prohibited • Unauthorized groundwater well drilling prohibited • Any activities that interfere with remedy actions prohibited except when in accordance with RFLMA	This RAO was met for this FYR period. Institutional controls recorded in the environmental covenant have been effective in preventing domestic and irrigation use of groundwater from the COU. The results of RFLMA routine inspections confirm that no unauthorized intrusive activities have occurred at the COU during this FYR period (Section 6.1.1).

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Table 4. Fourth FYR RAO Status (continued)

RAO	Remedy	FYR Status
Surface Water		
1. Meet surface water quality standards, which are the Colorado Water Quality Control Commission surface water standards.	• Surface water monitoring at POCs	The WALPOC 12-month rolling average for U exceeded the RFLMA standard for a 4-month period in 2014/2015 (Section 6.1.3). Consultation with the RFLMA parties (CR 2015-01) resulted in a plan to evaluate the condition to ensure the remedy remained protective. Evaluation of the Walnut Creek drainage system suggests that the increase in U concentrations may be attributable to heavy precipitation events that increase the mobility of U and increase the volume of groundwater discharged to surface water (Wright Water Engineers 2015). The remedy remains protective because (1) the reportable condition was a short-term occurrence associated with an extreme weather event, (2) exceedance of the 12-month rolling average for U is not anticipated to occur with any regularity in the future, and (3) the RFLMA standard for U is based on human health risk from long-term (chronic) exposure. As such, no unacceptable exposures occurred, or are expected to occur, as a result of the reportable condition.
Soil		
1. Prevent migration of contaminants to groundwater that would result in exceedances of groundwater RAOs.	• Groundwater monitoring at Sentinel wells • Groundwater treatment prior to reaching surface water	Sentinel well data exceeded RFLMA standards for some VOCs, nitrate, or uranium. Optimization and technical improvement opportunities at the SPPTS, MSPTS, and ETPTS were identified and implemented during this FYR period through the RFLMA consultative process (CRs 2012-02, 2014-01, 2014-04, 2014-08, 2015-04, 2015-08, 2015-09, and 2016-02). Optimization of the systems has resulted in reductions of nitrate and VOC concentrations in treated groundwater (see Section 6.1.4.3). Evaluation of groundwater treatment system monitoring and operation is summarized in Appendix E.

Table 4. Fourth FYR RAO Status (continued)

RAO	Remedy	FYR Status
2. Prevent migration of contaminants that would result in exceedances of surface water RAOs.	• Repair and maintenance of landfill covers, vegetation • Ongoing protection of remedy components	This RAO was met for this FYR period. Institutional controls are in place to prohibit soil disturbance without appropriate controls. Inspection and monitoring at the PLF indicate that the landfill cover and storm-water management system remain intact and effective in preventing unacceptable exposure to buried wastes. The PLFTS is operating as designed and is generally effective in removing trace VOCs from groundwater and seeps at the landfill. Although some constituents in PLFTS effluent were detected above the applicable RFLMA standards during this FYR period, these occurrences were short-lived and did not impact downstream surface water quality. A reportable condition relating to the effectiveness of the OLF cover was identified in 2013. The RFLMA parties consulted on this condition multiple times throughout this FYR period, several repairs to the OLF storm-water management system were completed (Section 6.1.4.2), and additional actions are planned. The remedy at the OLF remains protective because (1) the cover is effective in preventing unacceptable exposure to buried wastes and (2) groundwater and surface water monitoring data collected during this FYR period do not suggest the hillside instability at the OLF has negatively affected groundwater or surface water quality in the long term.
3. (Part 1) Prevent exposures that result in an unacceptable risk to the wildlife refuge worker. The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at the site or multiple pathways of exposure (40 *Code of Federal Regulations* 300.430[e][2][i][A][2]). (Part 2) Prevent significant risk of adverse ecological effects.	(Part 1) • Repair and maintenance of landfill covers, vegetation • Ongoing protection of remedy components ICs: • Perimeter signage • Activity restrictions • Groundwater use restrictions • Digging restrictions • Construction restrictions (Part 2) • Repair and maintenance of landfill covers, vegetation • Ongoing protection of remedy components	(Part 1) This RAO was met for this FYR period. The land use and exposure assumptions for a wildlife refuge worker used in the comprehensive risk assessment remain valid, and human health risk remains below the 1×10^{-6} risk level (Section 6.2.2). Institutional controls and physical controls to prevent unacceptable exposures, including via the indoor air pathway, are in place and effective (Section 6.1.1). See PLF, PLFTS, and OLF status in Soil RAO 2 above. (Part 2) This RAO was met for this FYR period. The ecological risk assessment conclusions remain valid and indicate that soil conditions do not represent a significant risk of adverse ecological effects at the COU. No evidence of adverse biological conditions (e.g., unexpected mortality or morbidity) was observed during this FYR period (2012–2016). See PLF, PLFTS, and OLF status in Soil RAO 2 above.

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During this FYR period (2012–2016), there were no exceedances of RFLMA standards for constituents sampled at WOMPOC and no reportable conditions.

There were four reportable conditions for uranium at WALPOC during this FYR period: three involving the 30-day average and one involving the 12-month rolling average. The first reportable condition occurred in December 2013, when the 30-day average U concentration (16.9 µg/L) exceeded the RFLMA standard of 16.8 µg/L (CR 2014-05). Subsequent 30-day averages (17.0–21.9 µg/L) collected at WALPOC exceeded the standard until May 2014, when the 30-day average fell below the standard. Because the 12-month rolling average is calculated for a longer period, these 30-day averages caused the 12-month rolling average to subsequently become reportable for U in October 2014 (17.2 µg/L). The 12-month rolling average for U at WALPOC remained above the RFLMA standard (17.0–17.2 µg/L) until January 2015, when it fell below the standard. In January 2016, a reportable condition occurred at WALPOC when the 30-day average uranium concentration (16.9 µg/L) exceeded the RFLMA standard (CR 2016-01). Subsequent 30-day averages from routine samples collected at WALPOC remained above the standard (16.9–19.0 µg/L) until March 2016. From late March until early December 2016, the 30-day uranium averages were below the RFLMA standard. The 12-month rolling averages for this time period (January through early December 2016) did not exceed the standard. In early December 2016, the 30-day average for U at WALPOC (16.9 µg/L) exceeded the RFLMA standard (CR 2017-02).

Figure 5 presents the uranium data for WALPOC from 2011 through the end of 2016. For each reportable condition, DOE consulted with EPA and CDPHE and developed a plan for responding to the condition (CRs 2014-05, 2015-01, 2016-01, and 2017-02). The plans included the collection of additional surface water samples from WALPOC and locations upstream and the addition of high-resolution isotopic uranium analyses for selected samples. Data collected prior to mid-2015 to evaluate these reportable conditions were included in a comprehensive evaluation of the distribution, transport mechanisms, sources, and isotopic composition of U in North and South Walnut Creeks (Wright Water Engineers 2015). Among other things, the study suggests a predictable relationship between precipitation and U concentrations in surface water. Specifically, heavy precipitation events (1) increase the mobility of U in soil which allows increased migration of U to groundwater, (2) increase groundwater discharge to surface water, and (3) increase U concentrations in surface water once direct runoff has diminished. Assessment of the Walnut Creek data shows that significant precipitation events such as those experienced in 2013 and 2015 result in an initial lowering of uranium concentrations in surface water due to increased runoff, followed by an increase in uranium concentrations over a prolonged period due to increased mobilization of uranium via geochemical mechanisms and increased volumes of groundwater reaching surface water. This effect was seen after the September 2013 event in which 30-day average U concentrations were first detected at reportable levels in December 2013 and did not return to concentrations below the RFLMA standard until approximately 5 months later in May 2014 (Figure 5). As of the end of this FYR period (December 2016), the 30-day average for U is above the RFLMA standard and the 12-month rolling average for U is below the standard.

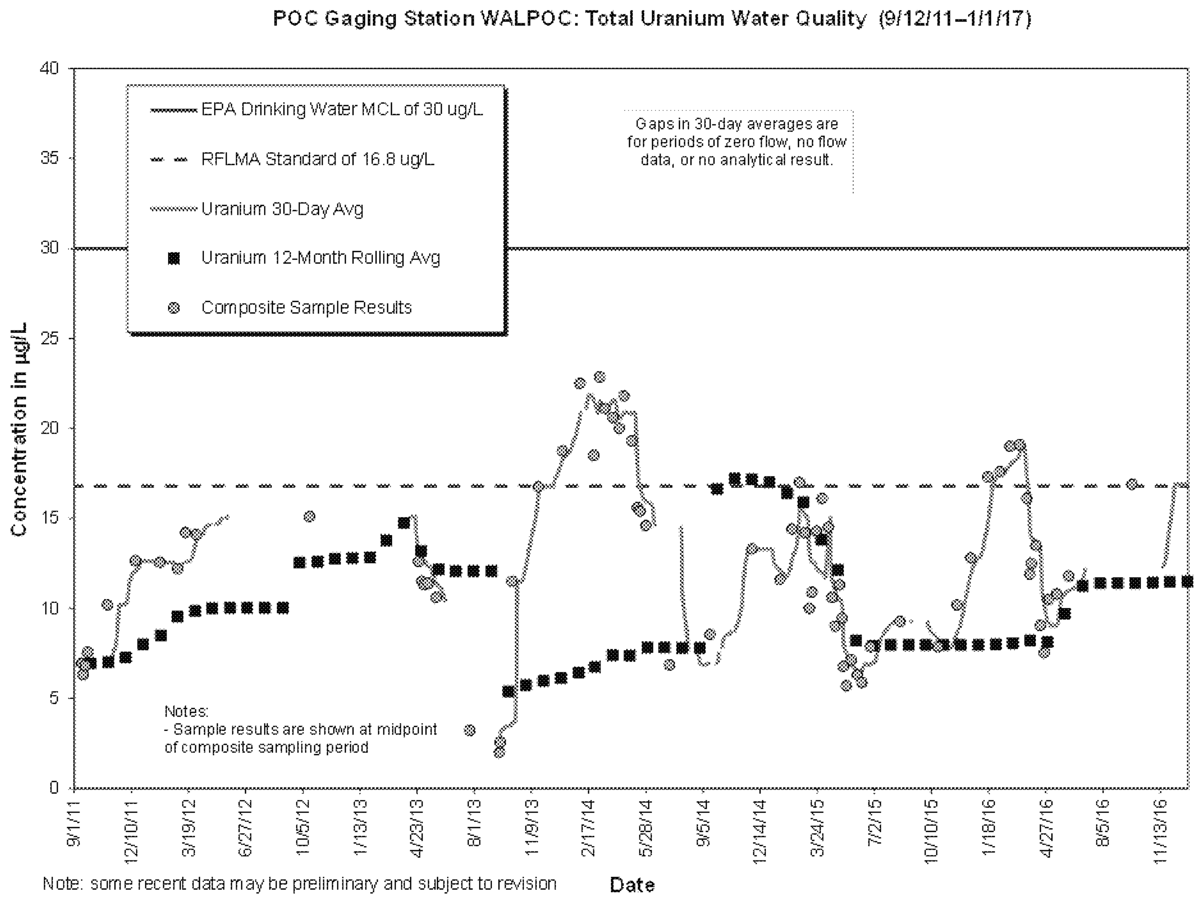

Figure 5. Uranium Concentrations at WALPOC

Other information considered during the RFLMA evaluation of the U reportable conditions at WALPOC includes the following:

(1) Data do not suggest a new source of U contamination

(2) Uranium concentrations at WALPOC ultimately decreased to below the RFLMA standard

(3) Not all uranium detected at WALPOC is contamination from former RFP operations (i.e., measured U concentrations at WALPOC are an average of 75% naturally occurring uranium [Wright Water Engineering 2015])

(4) All exceedances were well below the EPA maximum contaminant level (MCL) for U in drinking water of 30 µg/L

Although the MCLs are not directly applicable to the COU, comparison with the drinking water standard offers perspective on the quality of surface water before it leaves the COU.

While both the 30-day average and 12-month rolling average are calculated for the POCs, the RFLMA states that the 12-month rolling average is used in the evaluation of remedy performance. The evaluation of remedy performance in light of the 12-month rolling average exceedance for U at WALPOC concluded that the remedy remains protective. This conclusion was based on the following considerations:

(1) The reportable condition was a short-term occurrence associated with an extreme weather event

(2) Exceedance of the 12-month rolling average for uranium is not anticipated to occur with any regularity in the future

(3) The RFLMA standard for uranium is based on human health risk from long-term (chronic) exposure

As such, no unacceptable exposures occurred, or are expected to occur, as a result of the reportable condition.

6.1.4 Operation and Maintenance of Remedy Components

The engineered components of the remedy include the two landfill covers and the groundwater treatment systems. The operation and maintenance of the PLF and OLF covers are directly relevant to soil RAOs 2 and 3; groundwater treatment system operation and maintenance are directly relevant to groundwater RAO 2 and soil RAO 1.

6.1.4.1 Present Landfill

The Present Landfill was closed in 2005 and includes a RCRA-compliant composite cover, monitoring wells, and the PLF groundwater treatment system (PLFTS). The locations of the PLF and PLFTS are shown in Figure 6. The PLFTS consists of a passive air stripper (an arrangement of concrete steps over which the seep water flows) designed to treat VOCs. The PLFTS treats landfill seep water, surface water runoff, and groundwater intercepted by the Groundwater Intercept System, which was constructed to minimize upgradient flow into the PLF.

The evaluation of remedy performance at the PLF considers monitoring data from upgradient and downgradient RCRA wells, the PLFTS, downstream surface water location NNG01, and information obtained in routine inspections.

The inspection frequency for the PLF is quarterly, and settlement monuments are surveyed annually. The PLF inspection includes groundwater and surface water monitoring facilities, subsidence and consolidation, slope stability, soil cover, storm-water management structures, and erosion in surrounding features. During this FYR period, no notable conditions were observed during PLF inspections. Because vegetation success criteria were met at the PLF prior to the third FYR report, PLF-specific vegetation inspection requirements were discontinued at the PLF as recommended in the third FYR report (see CR 2014-03). Vegetation at the PLF is still inspected as part of the COU vegetation inspection efforts, in accordance with the *Rocky Flats, Colorado, Site Vegetation Management Plan* (DOE 2012b).

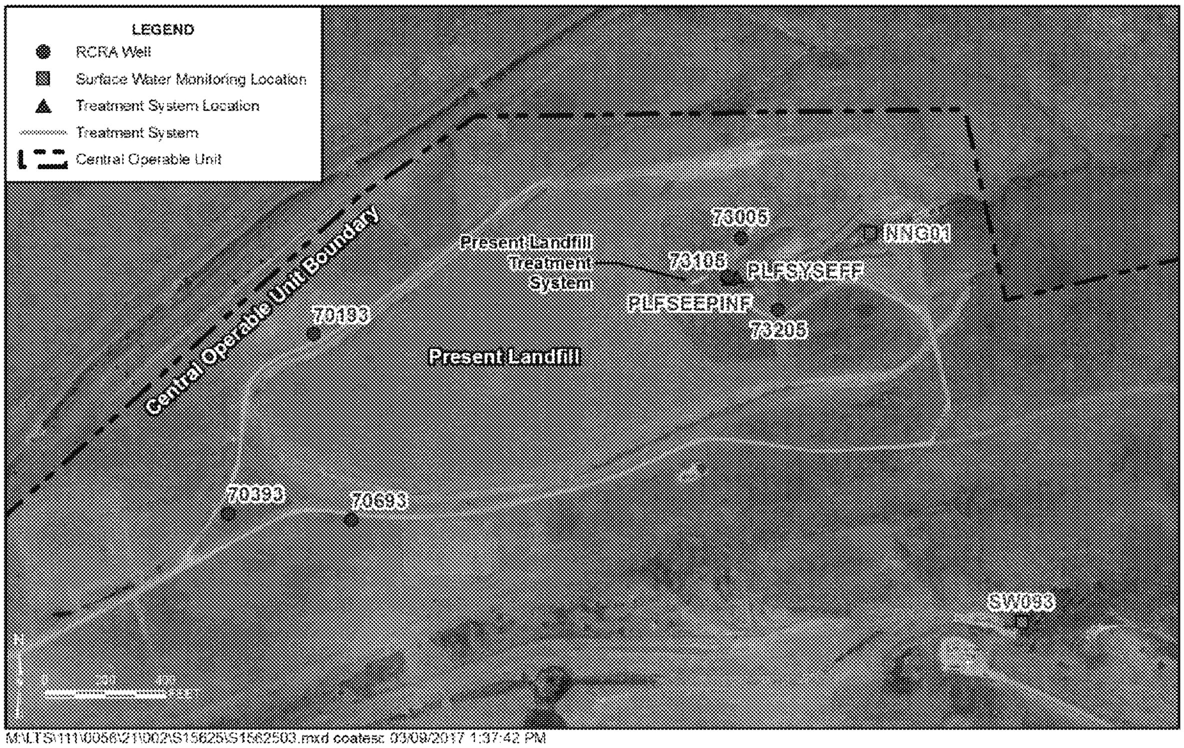

Figure 6. PLF Monitoring Locations

There are three upgradient and three downgradient RCRA groundwater monitoring wells at the PLF (Figure 6). These wells are sampled for VOCs and metals on a quarterly basis. The RFLMA Attachment 2 decision logic flowchart Figure 10, "RCRA Wells" (Appendix B), is relevant to these data. RFLMA requires that statistical analyses be conducted on RCRA well data from the PLF (and OLF) to compare constituent concentrations in groundwater at upgradient and downgradient RCRA wells and to determine concentration trends in downgradient wells. These statistical evaluations are conducted annually and are presented in the corresponding COU annual reports. The results of these analyses for each year in this FYR period are very similar, with several metals at higher concentrations downgradient than upgradient of the landfill, and in some cases, increasing metals concentration trends in downgradient wells. The full report of each analysis may be found in the COU annual reports. The RFLMA parties consulted annually during this FYR period regarding these results, and no actions were required other than continued monitoring and evaluation (see CR 2011-03).

RFLMA requires monitoring of the influent and effluent from the PLFTS to assess the operation of this passive treatment system. The influent and effluent locations are sampled on a quarterly basis for VOCs, metals, and uranium; the effluent location is also sampled for semivolatile organic compounds. The RFLMA Attachment 2 decision logic flowchart Figure 11, "Groundwater Treatment Systems" (Appendix B), is relevant to these data. Arsenic and selenium were detected above RFLMA standards intermittently in PLFTS effluent throughout this FYR period, triggering additional sampling in each instance. Subsequent effluent sample results were below RFLMA standards, so consultation with the RFLMA parties was not required. Vinyl chloride was detected above the RFLMA standard in PLFTS effluent for three consecutive months in both 2014 and 2015 (CRs 2014-06 and 2015-07). Consultation with the RFLMA parties was initiated, and surface water samples were collected downstream of the PLFTS at location NNG01 (Figure 6). Vinyl chloride was not detected in either of the surface water samples from location NNG01. The RFLMA parties determined that no further action was required to address the vinyl chloride observations. PLFTS effluent meets the applicable RFLMA standards at the end of this review period.

The remedy at the PLF remains protective of human health and the environment. The landfill cover and storm-water management system at the PLF remain intact and effective in preventing unacceptable exposure to buried wastes. Monitoring data at the PLFTS indicate that the system is operating as designed and is generally effective in removing trace VOCs from groundwater and seeps at the landfill. While some constituents in PLFTS effluent were detected above the applicable RFLMA standards during this FYR period, these occurrences were short-lived and did not impact downstream surface water quality.

6.1.4.2 Original Landfill

The Original Landfill was closed in 2005 with a soil cover and storm-water management features designed to achieve hillside stability and control precipitation run-on and runoff. The location of the OLF with respect to the COU is shown in Figure 2. The evaluation of remedy performance at the OLF considers monitoring data from upgradient and downgradient RCRA wells, upstream and downstream surface water locations GS05 and GS59, and information obtained in routine inspections.

The current inspection frequency for the OLF is monthly, and settlement monuments are surveyed quarterly. Additional inspections are required following specific weather events defined in the RFLMA. Inspection information includes groundwater and surface water monitoring facilities, subsidence and consolidation, slope stability, soil cover, storm-water management structures, and erosion in surrounding features. Because vegetation success criteria were met at the OLF prior to the third FYR report, OLF-specific vegetation inspection requirements were discontinued as recommended in the third FYR report. Vegetation at the OLF is still inspected as part of the COU vegetation inspection efforts, in accordance with the *Rocky Flats, Colorado, Site Vegetation Management Plan* (DOE 2012).

The natural geologic and hydrologic conditions at the OLF make it prone to slumping and settling that can be exacerbated by heavy precipitation events. These conditions existed before waste was first placed on the hillside in the early 1950s. After closure of the OLF in 2005, the hillside remained stable until 2007, when landfill inspections identified localized slumping and settling in the westernmost portion of the cover following the extremely heavy snowfall accumulation of winter 2006/2007 and the resultant early 2007 runoff. These conditions triggered the RFLMA consultative process and are discussed in CR 2008-07 and the third FYR report (DOE, EPA, and CDPHE 2012). The plan for addressing these conditions included repairs to the landfill and further investigation to determine if the conditions were likely to influence the integrity of the OLF cover. The resulting geotechnical investigation concluded that, according to slope stability modeling, the large-scale overall slope at the OLF was stable and the risk of large-scale failure of the OLF was low (TtT 2008).

Following a week-long rain event in the fall of 2013, a weather-related inspection of the OLF identified localized surface cracking and settlement on the northeastern edge of the OLF hillside.

These conditions resulted in a RFLMA reportable condition for the OLF (CR 2013-02), triggering the RFLMA consultative process. Maintenance actions were taken to repair the settlement, and the East Perimeter Channel (EPC) was reconfigured (CRs 2013-03 and 2014-09). An extended period of relatively heavy precipitation occurred in the spring of 2015, resulting in extensive movement on the eastern edge of the OLF hillside. As with previous slumping, most of this movement occurred outside the waste footprint. Maintenance was completed in accordance with the OLF Monitoring and Maintenance Plan in the fall of 2015 (CRs 2015-03 and 2015-06). In the spring of 2016, the OLF hillside showed signs of movement in the southeast corner. Although this movement was not as significant as the movement noted in 2015, it was determined that further maintenance at the OLF was warranted and the EPC and landfill berms were regraded and repaired in October 2016. Additional maintenance was completed at the East Subsurface Drain (ESSD), located in the northeast corner of the EPC, in early January 2017 (CR 2016-04). In response to the slumping, cracking, and displacements that have occurred at the edges of the landfill, LM initiated a multifaceted effort to further evaluate the stability of the slopes surrounding the OLF. Two geotechnical firms were contracted to independently assess and provide recommendations for stabilizing the hillside. The resulting geotechnical reports are attachments to the *Original Landfill Path Forward Rocky Flats Site, Colorado* report that was published in January 2017. This report provides recommendations for a phased approach to the evaluation and implementation of options for minimizing slope movement at the OLF (DOE 2017).

There are three downgradient and one upgradient RCRA groundwater monitoring wells at the OLF (Figure 7). These wells are sampled for VOCs, semivolatile organic compounds, and metals on a quarterly basis. The RFLMA Attachment 2 decision logic flowchart Figure 10, "RCRA Wells" (Appendix B), is relevant to these data. As with the PLF RCRA wells, statistical analyses for OLF RCRA well data were very similar for each year within this FYR period, with several metals detected at higher concentrations downgradient than upgradient of the landfill, and in some cases, increasing metals concentration trends in downgradient wells. The full report of each statistical analysis may be found in the COU annual reports. DOE has consulted with EPA and CDPHE annually on these results, and no action has been required other than continued monitoring and evaluation (see CR 2011-03).

Monitoring at the OLF also includes the collection of surface water samples at locations upstream (GS05) and downstream (GS59) of the landfill (Figure 7). These locations are sampled at least quarterly for VOCs, uranium, and metals. The RFLMA Attachment 2 decision logic flowchart Figure 12, "Original Landfill Surface Water" (Appendix B), is relevant to these data. During this FYR period, there were three instances when downstream sample results for metals at location GS59 triggered monthly sampling. In the fourth quarter of 2013, selenium was detected at 5.5 µg/L, above the RFLMA standard of 4.6 µg/L. All subsequent samples from GS59 were below the standard until the third quarter of 2015, when both selenium (6.7 µg/L) and arsenic (10.6 µg/L) were detected above the RFLMA standards of 4.6 and 10 µg/L, respectively. Subsequent samples did not exceed the selenium or arsenic standards, and no further action was required. In the fourth quarter of 2016, selenium was detected at location GS59 at 8.03 µg/L. Monthly sampling at GS59 began in January 2017. The results of surface water monitoring at the OLF for each year in this FYR period may be found in COU annual reports.

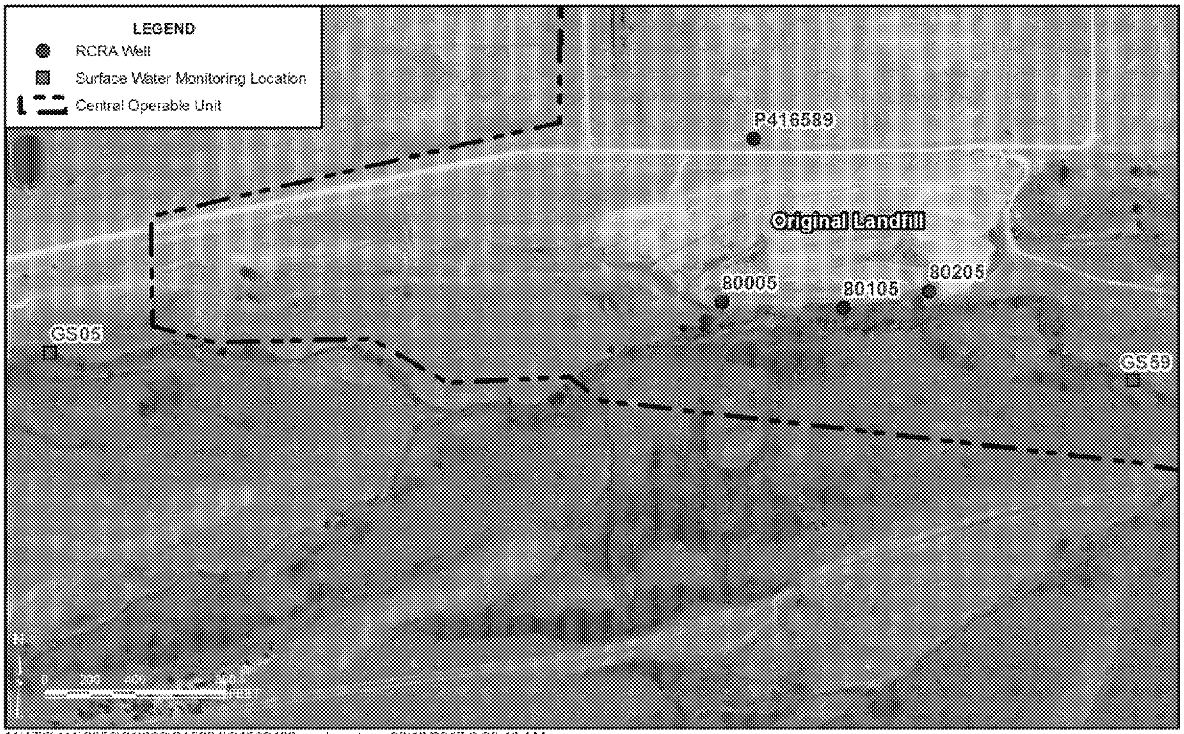

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Figure 7. OLF Monitoring Locations

In summary, routine and weather-related inspections at the OLF identified substantial, localized slumping and cracking along the eastern and western edges of the landfill during this FYR period. While hillside movement was more extensive than in the previous FYR period (2007–2012), the central portion of the OLF has remained stable. Repair and maintenance activities have occurred throughout this FYR period in response to OLF conditions and will continue as necessary. While the majority of the cracking and slumping has occurred on the periphery of the OLF, seeps and cracks have been identified within the waste footprint. The remedy at the OLF remains protective. No unacceptable exposures to personnel working at the COU have occurred as a result of these conditions. Occupational exposure to personnel working at the OLF to implement the various repairs and maintenance operations is closely monitored and documented in the site records. Physical controls required by the remedy effectively control access to the COU, minimizing the potential for inadvertent access to the OLF by unauthorized parties. Institutional controls specific to the two landfills in the COU, including the OLF, prohibit unauthorized activities on the landfill covers to ensure that unacceptable exposures do not occur. Furthermore, groundwater and surface water monitoring data collected during this FYR period suggest the hillside instability at the OLF has not negatively affected groundwater or surface water quality in the long term.

6.1.4.3 Groundwater Treatment Systems

The remedy in the CAD/ROD included the four groundwater treatment systems operating at the time the COU was closed in 2005: the Present Landfill Treatment System (PLFTS), the Solar Ponds Plume Treatment System (SPPTS), the Mound Site Plume Treatment System (MSPTS), and the East Trenches Plume Treatment System (ETPTS). The treatment systems remove target contaminants from groundwater (VOCs, nitrate, or uranium) and reduce contaminant load to surface water. Each groundwater treatment system is monitored, at a minimum, for untreated influent and treated effluent, and for impacts to surface water downstream of the effluent discharge points. Monitoring data associated with the groundwater treatment systems is evaluated in accordance with RFLMA Attachment 2 decision logic flowchart Figure 11, "Groundwater Treatment Systems" (Appendix B). The discussion of influent, effluent, and surface water monitoring results for this FYR period for the SPPTS, MSPTS, and ETPTS is found in Appendix E; PLFTS monitoring data are discussed in Section 6.1.4.1.

A detailed description of each system configuration at the beginning of this FYR period may be found in the third FYR report (DOE, EPA, and CDPHE 2012). Several opportunities for groundwater treatment system optimization were identified and implemented during this FYR period through the RFLMA consultative process. Treatment system modifications are discussed in CRs 2012-02, 2014-01, 2014-04, 2014-08, 2015-04, 2015-08, 2015-09, and 2016-02 (Appendix D). No changes to the PLFTS were made during this FYR period. A summary of treatment system changes implemented during this FYR period is presented below; the progression of system changes following closure of the COU may be found in the annual reports.

- **SPPTS.** Since the COU closed in 2005, this treatment system has been the focus of extensive study and modification. Evaluation of the system was necessary due to the poor performance of the original sawdust and zero-valent iron (ZVI) treatment media in meeting post-closure surface water standards and the cost and difficulty in maintaining the system. Changes to the system during this FYR period included the removal of existing treatment media, conversion of the system to a full-scale, interim design bioremediation lagoon to treat nitrate, and small-scale treatability studies using various reactive media to remove uranium. At the end of this FYR period, the lagoon conversion has shown promising results in the removal of nitrate. In fact, in the last 12 consecutive weekly samples of SPPTS effluent collected through the end of 2016, nitrate was not detected. Uranium treatability studies are ongoing.

- **MSPTS and ETPTS.** Each of these two systems originally utilized ZVI treatment media. While this media was effective in reducing contaminant load in groundwater, it proved less effective in consistently reducing VOCs to meet the RFLMA water quality standards. As with the SPPTS, media removal and disposal was costly and labor-intensive. Opportunities for VOC treatment optimization were identified and implemented for the MSPTS and ETPTS through the RFLMA consultative process. To test VOC removal potential, small air strippers were added to the MSPTS in 2011(CR 2011-01) and ETPTS in 2013 (CR 2012-02). Based on the success of these air strippers, the MSPTS and ETPTS were reconfigured at different times to replace ZVI treatment with a single commercial air stripper located at the ETPTS (CRs 2014-01, 2015-04, 2016-02). Following completion of this project in late 2016, VOC concentrations in combined MSTPS and ETPTS effluent have met all applicable RFLMA standards. Because this most recent reconfiguration changed the location of groundwater treatment of the Mound Site plume from the MSPTS to the ETPTS, this modification was considered a significant difference to the selected remedy for the MSPTS. The significant difference was documented in an Explanation of Significant Differences (see CR 2016-02).

  The reconfiguration of the MSPTS and ETPTS has increased the systems' resilience to weather variability and extremes. Because the COU has no line power available, treatment components are powered entirely by solar energy via solar panels and batteries, which are designed to limit power interruptions and allow for operation in all weather conditions. Unlike the previous gravity-fed, passive design that resulted in treatment effectiveness varying with groundwater flow rates, the reconfigured ETPTS operates in a batch treatment mode, and the air stripper treats at a constant flow rate. The result is that treatment is no longer dependent on residence time within the media and can accommodate a wide range of groundwater flows while achieving the same level of treatment. Treating the groundwater in batches ensures that groundwater processed through the system receives a consistent level of treatment. The reconfigured system provides more control over the treatment of the Mound and East Trenches groundwater plumes, thus providing additional flexibility in accomplishing treatment. The MSPTS, ETPTS, and SPPTS collection systems and the ETPTS and SPPTS treatment systems feature remote-access monitoring capabilities that allow for the automatic of individual system components in response to changing conditions (e.g., increase in groundwater volumes).

6.1.5 Operations and Maintenance Costs

The O&M cost of the selected remedy was estimated in the Remedial Investigation/Feasibility Study Report and presented in the 2006 Proposed Plan. The total annual estimated O&M costs in 2005 dollars were $2,757,000, which included groundwater treatment systems media replacement estimated at $728,000 every 5 years for each of the three systems.

The remedy-related implementation cost for this review period was compiled using actual cost for fiscal years 2012–2016. While this does not correspond exactly to the period for which environmental data was evaluated, it is representative of the cost to maintain the remedy over a 5-year period. The following O&M and capital costs incurred during this review period were included in the evaluation:

- Groundwater and surface water monitoring
- Operation, inspection, and maintenance of the groundwater treatment systems
- Inspection and monitoring of the remedy-related physical and institutional controls
- RFLMA-required data collection and reporting, including public participation activities
- Implementing the RFLMA consultative process
- Conversion of the ETPTS from ZVI-based treatment to a solar-powered commercial air stripper
- Installation of infrastructure to route water from the MSPTS collection trench to the ETPTS air stripper, thus eliminating the need for the ZVI-based treatment system for the Mound Site plume
- Removal of the original treatment media at the SPPTS and conversion to a full-scale test system for nitrate treatment using biological processes
- Continuation of technology investigations for uranium treatment at SPPTS
- OLF and PLF inspections and cover vegetation management, including weed control
- OLF soil cover and diversion berm repairs and maintenance
- OLF maintenance following heavy precipitation events in 2013, 2015, and 2016

- Geotechnical evaluation and path forward recommendation for additional actions to improve hillside stability at OLF
- Erosion controls, subsidence repair, and revegetation monitoring
- Conduct of the FYR
- Geochemistry evaluation for water quality in Walnut Creek
- Evaluation of reportable conditions at WALPOC, SW027, GS10, and AOC well 10304 including investigation monitoring, and seeding and erosion controls at the SW027 drainage
- Monitoring and consultation regarding threatened and endangered species and wetlands
- Water monitoring equipment capital costs and maintenance
- Project management and overhead costs

Total O&M and capital cost for this period is approximately $17.9 million. The RI/FS Report projected that the 5-year cost for implementing the selected remedy would be approximately $13.6 million, in unescalated 2005 dollars. The remedy implementation costs are higher than the projected costs for this 5-year review period due to the following factors:

- The original groundwater treatment systems were passive systems designed to require limited human interaction; the current systems, which provide significantly more effective treatment, also require more labor for O&M.
- Two groundwater treatment systems that were not always effective in meeting treatment targets were converted from ZVI-based treatment systems to air stripper-based technology that is very effective in meeting treatment targets and does not generate a large volume of spent ZVI for disposition.
- The full-scale nitrate test system at SPPTS had significant up-front reconfiguration cost but is now effectively treating nitrate and does not require disposition of a large volume of spent treatment media.
- OLF maintenance requirements during this review period were significantly higher than projected due to the slumping and cracking on the east and west edges experienced after the high precipitation events in 2013, 2015, and 2016. Additional evaluation and activities are underway to determine methods to minimize future movement.
- Geochemistry evaluation led to a better understanding of mechanisms affecting uranium and nitrate concentrations in Walnut Creek.
- Additional staff was added to support the activities performed during this 5-year period.
- Escalation since 2005.

The additional costs incurred over this FYR period do not suggest problems with the remedy because:

(1) The costs for converting the MSPTS, ETPTS, and the SPPTS nitrate treatment component are one-time costs to reconfigure the systems to provide more effective treatment with significantly less waste generation. This initiative was implemented as an opportunity for optimization of the remedy.

(2) OLF maintenance costs include evaluation of options to minimize slope movement in the future to maintain protectiveness.

(3) Some of the cost increase is due to 12 years of price escalation since the RI/FS costs were developed.

6.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Still Valid?

Based on the evaluation presented in this section, the exposure assumptions, toxicity levels, cleanup levels, and RAOs used at the time of the remedy are still valid, and revision of the RAOs is not necessary. There were no changes in exposure pathways or assumptions during this FYR period; land use in the COU remains consistent with the Rocky Flats Wildlife Refuge land use assumption in the CAD/ROD. There were some revisions to surface water quality standards and toxicity levels, which are discussed in the sections below.

6.2.1 Evaluation of Changes in Standards

A review of the CAD/ROD ARARs was conducted to determine whether there were any promulgated changes to statutes or regulations relevant to the chemicals, locations, or actions addressed by the CAD/ROD during this FYR period. Appendix H is a table of changes to CAD/ROD ARARs and other potentially applicable regulations that were considered in this FYR evaluation.

The remedy performance standards for surface water and groundwater at the COU are the Colorado surface water quality standards identified as ARARs in the CAD/ROD. These standards are directly relevant to groundwater RAOs 1 and 2, surface water RAO 1, and soil RAOs 1 and 2 (Table 4). Newly promulgated or modified ARARs contribute to the evaluation of protectiveness and must be considered in the FYR.

6.2.1.1 Surface Water Standards

The surface water standards applicable to the COU are based on (1) Colorado Water Quality Control Commission (WQCC) regulation No. 31, "Colorado Basic Standards and Methodologies for Surface Waters" (Volume 5 *Code of Colorado Regulations* Regulation 1002-31 [5 CCR 1002-31]), which are statewide basic standards, and (2) Colorado WQCC regulation No. 38, "Classification and Numeric Standards South Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin" (5 CCR 1002-38), which are site-specific standards. The Walnut and Woman Creek portions in the COU are Big Dry Creek segments 4a and 5 of the South Platte River Basin. Because the use classification of groundwater in the COU is surface water protection, the applicable surface water standards also apply to groundwater.

The surface water standards for eight chemical constituents were revised in this FYR period (see CR 2012-03). The standards for five of these constituents (acrylamide, carbon tetrachloride, hexachloroethane, nitrobenzene, and tetrachloroethene) increased (i.e., are now less stringent). Therefore, the remedy remains protective. The standard for *cis*-1,2-dichloroethene was changed to a range of concentrations (0.014–0.070 milligram per liter [mg/L]). After consultation with the RFLMA parties, the higher number in the range (0.070 mg/L) was retained as the RFLMA surface water standard. The higher standard was the same as the previous RFLMA standard for *cis*-1,2-dichloroethene; therefore, the remedy remains protective. The standards for two constituents (1,4-dioxane and pentachlorophenol) decreased from the previous standards (i.e., are now more stringent). These two constituents were not identified as analytes of interest in any media at the COU or POU in the RI/FS Report (DOE 2006), nor were they identified as contaminants of concern (COCs) in the CRA; routine monitoring for these constituents is not required by RFLMA. Limited data from groundwater and treatment system monitoring during this FYR period show pentachlorophenol as nondetect in all samples; no data for 1,4-dioxane is available. Therefore, a change in the standards for these two constituents does not affect protectiveness of the remedy.

6.2.2 Evaluation of Changes in Toxicity Data

The remedy performance standards for soil in the COU are site-specific, risk-based values calculated using the exposure assumptions for a wildlife refuge worker (WRW). These standards, referred to as preliminary remediation goals (PRGs), were used to identify COCs within the COU and are directly relevant to the evaluation of soil RAO 3 (Table 4). The risks posed by the COCs left at the COU following accelerated actions were evaluated in a comprehensive risk assessment (CRA) in 2006 (DOE 2006).

The CRA evaluated the land area that encompasses the POU and the COU, divided into 12 exposure units (EUs) (Appendix C, Figure C-1). The comprehensive risk assessment was completed by exposure unit and not by operable unit (POU and COU). As shown in Table 5, half the EUs overlap both the COU and POU while the rest are confined only to the POU. Table 5 summarizes all COCs (chemical and radiological) for each exposure unit for which risks were evaluated in the CRA. These are constituents for which residual soil concentrations exceeded PRGs. It should be noted that no chemical COCs were identified for the POU.

The PRGs developed for the COU represent the maximum concentrations for individual chemical constituents and radionuclides that would equate to a carcinogenic risk value of 1×10^{-6} or a noncarcinogenic hazard quotient of 0.1 based on the exposure assumptions for the WRW. The risk value represents the added probability that an individual or population will develop cancer during their lifetime as a result of exposure to site contaminants. The acceptable risk range for CERCLA sites is an added risk of less than 1 in 1,000,000 (1×10^{-6}) to a maximum of 1 in 10,000 (1×10^{-4}). If cumulative risks (i.e., risks posed by all pathway and contaminants summed together) for a site are within or below the acceptable risk range, further action is generally not needed. The PRGs are conservative screening values for identifying individual contaminants that require further evaluation. Generally, if the concentration of a single contaminant is less than (or below) its PRG value, no further evaluation is required. If the concentration of a contaminant is greater than (or above) its PRG value, then further evaluation of the potential risks posed by the contaminant is appropriate. The PRGs for the COU were developed using toxicity levels that were current at the time of the CRA and were developed for exposures to both surface and subsurface soils. Changes to the risk parameters (e.g., slope factors, reference doses) used to calculate these PRGs may impact the identification of COCs and must be considered in the FYR.

Table 5. Surface Soil COCs Identified for Each Exposure Unit in the CRA

Constituent	Exposure Unit											
	Industrial Area EU	Upper Woman Drainage EU	Wind Blown EU	No Name Gulch EU	Upper Walnut Drainage EU	Lower Woman Drainage EU	Rock Creek EU	Lower Walnut Drainage EU	Inter Drainage EU	West Area EU	Southwest Buffer Zone Area EU	Southeast Buffer Zone Area EU
Part of COU	•	•	•	•	•	•						
Part of POU	•	•	•	•	•	•	•	•	•	•	•	•
Arsenic	X	-	X	-	-	-	-	-	-	-	-	-
Vanadium	-	-	-	X	-	-	-	-	-	-	-	-
2,3,7,8-TCDD	-	X	-	-	-	-	-	-	-	-	-	-
Benzo[*a*]pyrene	X	X	-	-	X	-	-	-	-	-	-	-
Plutonium-239/240	-	-	X	-	-	-	-	-	-	-	-	-

Abbreviations:
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-*p*-dioxin
X = constituent designated a COC in the 2006 CRA
- = constituent not designated a COC in the 2006 CRA

6.2.2.1 Chemical Constituents

The COC identification process used in the comprehensive risk assessment was reviewed using updated EPA soil screening values comparable to the wildlife refuge worker PRGs. Generally, the evaluation confirmed that the surface soil COCs identified in the CRA remain the primary risk drivers in the COU. It also confirmed that there are no subsurface soil COCs. The toxicity levels for the COCs were reviewed by comparing current toxicity levels with that used during the CRA. A comparison of the CRA and current toxicity levels is provided in Table 6.

There have been some changes in toxicity levels for some constituents since the comprehensive risk assessment; however, these do not affect the protectiveness of the remedy for the COU. EPA has revised its methodology for determining risks associated with the inhalation pathway for both carcinogens and noncarcinogens. However, for chemical constituents, the inhalation pathway has much less affect for the wildlife refuge worker than the oral ingestion pathway and does not impact the estimation of overall risks within the COU. The toxicity levels for the oral ingestion pathway have not changed for arsenic and benzo[*a*]pyrene. The EPA oral reference dose for vanadium is higher than that used in the CRA, meaning that current estimated risks would be lower. A new reference dose has been added for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) since the CRA. However, the elevated concentrations of dioxin were associated with the OLF prior to construction of the cover and are not present on the surface. Thus, the pathway to residual dioxin contamination has been severed, and changes in toxicity levels do not affect remedy protectiveness. This evaluation confirms that conclusions reached in CAD/ROD are still valid and the COU remains protective for the WRW.

Table 6. Comparison of COC Toxicity Values

COC	Carcinogenic Toxicity Values				Noncarcinogenic Toxicity Values			
	Oral/Ingestion[a]		Inhalation		Oral/Ingestion[d]		Inhalation	
	CRA	Current	CRA[b]	Current[c]	CRA	Current	CRA	Current[e]
Arsenic	1.50	1.50	1.51×10^{1}	4.3×10^{-3}	3.00×10^{-4}	3.00×10^{-4}	n/a	1.5×10^{-5}
Vanadium	n/a	n/a	n/a	n/a	1.00×10^{-3}	9.00×10^{-3}	n/a	n/a
Benzo[*a*]pyrene	7.3	7.3	3.1	1.1×10^{-3}	n/a	n/a	n/a	n/a
2,3,7,8-TCDD	1.5×10^{5}	1.3×10^{5}	1.5×10^{5}	3.8×10^{1}	n/a	7.0×10^{-10}	n/a	4.8×10^{-8}

Notes:
[a] Oral slope factor $(mg/kg\text{-}day)^{-1}$.
[b] Inhalation slope factor $(mg/kg\text{-}day)^{-1}$.
[c] Inhalation unit risk $(\mu g/m^3)^{-1}$.
[d] Oral reference dose (mg/kg-day).
[e] Reference concentration (mg/m^3).

6.2.2.2 *Radionuclide Constituents*

Radiological Risk. Information from the current EPA PRG calculator was used in this FYR evaluation to determine if the risk from radionuclides to the wildlife refuge worker in the COU remains within the acceptable CERCLA risk range. The acceptable risk range for CERCLA sites is an added cancer risk of less than 1 in 1,000,000 (1×10^{-6}) to a maximum of 1 in 10,000 (1×10^{-4}). Information in the EPA PRG calculator includes the numerous changes to toxicity factors that have occurred since 2006, including revisions specific to plutonium and uranium. A summary of the methodology used and these changes, including changes to slope factors for the different exposure pathways, is provided in Appendix C. For completeness, this FYR radiological risk evaluation considered plutonium-239/240 (the only radionuclide COC identified in the 2006 CRA), americium-241, uranium-234, uranium-235, and uranium-238. The americium and uranium isotopes represent the other primary radionuclides associated with RFP historical operations.

To perform this FYR radiological risk evaluation, information from the 2017 EPA online calculator was used as a basis to generate site-specific PRGs using the input parameters from the 2006 CRA for the WRW at a 1×10^{-6} risk level. These values were then compared to the PRG WRW values in the 2006 CRA, which were also calculated at the 1×10^{-6} risk level. This methodology does not require input of site-specific analytical data because PRGs represent concentrations based on a target risk level rather than a calculated risk from measured concentrations. As such, no new analytical data were collected for this FYR risk evaluation. Details of the methodology used to complete this FYR evaluation are presented in Appendix C.

As evidenced in Table 7, the radiological PRGs calculated for this FYR evaluation are slightly higher than those calculated for the 2006 CRA. This means that the risk associated with residual radionuclides in the COU has slightly decreased due to changes in the slope factors and/or equations used in the 2017 PRG calculator. Therefore, while numerous changes have occurred to the EPA PRG calculator since 2006, the risk to the WRW from residual radionuclides in the COU is effectively the same as it was in 2006 (1×10^{-6}), at the lower (i.e., most protective) end of the acceptable risk range.

Table 7. PRG Comparison for Wildlife Refuge Worker in the COU (picocuries per gram [pCi/g] at 10^{-6} risk level)

Isotope	2006 CRA PRG	2017 PRG
^{241}Am	7.69	8.81
^{239}Pu	9.78	11.85
^{234}U	25.31	29.96
^{235}U	1.05	1.06
^{238}U	29.33	34.38

Radiological Dose. The CAD/ROD identified select Colorado radiation protection standards as ARARs for the COU. For radiological sites that do not allow for unrestricted use, as is the case for the COU, Colorado regulations require that institutional controls be in place that reasonably assure that the total effective dose equivalent from residual radioactivity within the COU does not exceed 25 millirems per year (mrem/year) (6 CCR 1007-4.61.2). In 2006, a dose assessment was completed for the COU using the RESRAD computer model, to determine if the COU met the 25 mrem/year dose criteria upon closure (DOE 2006). For this FYR, changes to input parameters (e.g., slope factors, dose conversion factors) used in the dose assessment were evaluated to determine if this ARAR continues to be met. The methodology used to complete this FYR review of radiological dose is described in Appendix C.

To understand the relative impact to dose resulting from the numerous changes to input parameters and the computer model that have occurred since 2006, a range of exposure scenarios and associated analytical data evaluated in the 2006 RESRAD (version 6.3) dose assessment was entered into the current RESRAD model (version 7.2). No new sample data to support this fourth FYR dose evaluation were collected.

A comparison of the RESRAD version 6.3 dose results to the RESRAD version 7.2 dose results indicates little change in total dose. All of the 2006 scenarios evaluated in Appendix C yielded similar results, suggesting that the changes in total dose for all scenarios and locations evaluated in 2006 would be negligible using the current RESRAD model version. This simply means that the changes to RESRAD since 2006 have not resulted in major impacts to dose calculated by the model. That is, the dose calculated using RESRAD version 6.3 is nearly the same as the dose calculated using RESRAD version 7.2, using the same 2006 site-specific input parameters. Therefore, because the dose assessment from 2006 indicated that the COU is in compliance with the dose criteria ARAR from the CAD/ROD with a total dose much less than 25 mrem/year, a recalculation of dose using the most updated version of RESRAD would yield similar results and the ARAR would still be met. The FYR dose assessment review concluded that the dose criteria ARAR is met and the remedy in the COU remains protective.

6.2.3 FYR Risk Evaluation Summary

The chemical and radiological risks to the wildlife refuge worker in the COU were reviewed in light of changes to toxicity factors that have occurred since the comprehensive risk assessment was published in 2006. Following are the key conclusions from this FYR risk evaluation:

- The risks posed to the wildlife refuge worker in the COU for chemical and radiological constituents remain within the acceptable risk range and, in fact, are at the very low (i.e., most protective) end of the risk range
- The changes in toxicity values and other input parameters did not affect the protectiveness of the remedy
- Exposure assumptions used are conservative and remain valid
- The general Site Conceptual Model and assumption that the most likely exposure scenario for a human receptor is approximated by a wildlife refuge worker scenario is still valid for the COU
- Institutional controls are in place at the COU that eliminate the vapor intrusion pathway
- RAOs and cleanup goals remain valid

Independent of the FYR risk evaluation of the COU described above, a review of risks in the POU and OU3 was also completed. This review confirmed that UU/UE determinations for the POU and OU3 are still valid. A summary of the review methodology and results is presented in Appendix C.

6.2.4 RAO Status

The status of each RAO during this FYR period is presented in Table 4. The RAOs and ARARs in the CAD/ROD remain relevant in addressing residual contamination and potential exposure pathways at the COU and assessing remedy protectiveness. Not all RAOs were met during this FYR period; however, the remedy is designed to achieve all RAOs in the long-term. No revisions to the RAOs established in the CAD/ROD are recommended.

6.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

No other information collected during this FYR period has called into question the protectiveness of the remedy.

The robustness of the remedy, however, was tested during this FYR period by the high variability in precipitation from year to year. In 2012, the COU experienced one of the driest years on record, followed in 2013 by a significant precipitation event and subsequent flooding, and a very wet spring in 2015. During 2013, the precipitation measured in the second and third quarters (13.86 inches) was 68.9% higher than historical (1997–2012) values for this time period. Much of this increase is due to a significant rain event and associated flooding that occurred September 11–15, 2013 (DOE 2014b). Most of the precipitation in 2015 was from multiple rain storms that occurred between April and July, when almost three-quarters of the total precipitation measured in 2015 was received; slightly over half of the annual moisture fell in the months of

May and June (DOE 2016). It should be noted that this precipitation information is based on data from unheated rain gages located in the COU and likely underestimates precipitation because snowmelt is not fully represented. The 2013 and 2015 precipitation events greatly increased the volume of surface water flow, as measured at the POCs (Figure 8) and the volume of groundwater treated in the groundwater treatment systems (Table 8).

6.3.1 Surface Water Flow and Runoff

The extreme variability in precipitation can be seen in the annual discharge volumes measured at the WOMPOC and WALPOC locations (Figure 8). Despite a very dry year (2012), a significant flooding event (2013), and a very wet spring (2015), the 12-month rolling averages for monitored constituents at WOMPOC and WALPOC were below applicable RFLMA surface water standards for the majority of this FYR period. In fact, there was only one short period in 2014/2015 that the 12-month rolling average for uranium exceeded the RFLMA standard at a POC. This occurred at WALPOC and may be largely attributed to groundwater recharge from the precipitation event in 2013. It should be noted that the maximum 12-month rolling average for uranium at WALPOC (17.2 µg/L) was only slightly above the RFLMA standard of 16.8 µg/L.

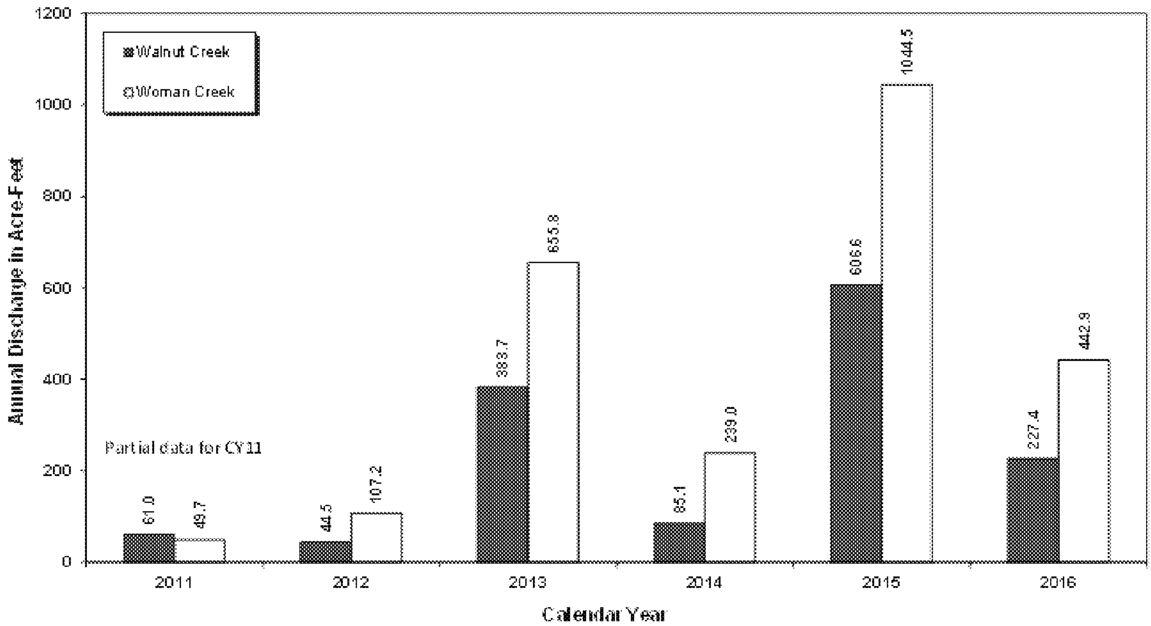

Figure 8. Annual Surface Water Discharge from WOMPOC and WALPOC

6.3.2 Groundwater Treatment Systems

The precipitation events in late 2013 and in 2015 led to increased groundwater flow to the groundwater treatment systems. While the 2013 event did not contribute as much recharge to the groundwater because so much of it ran off as surface flow, a substantial amount infiltrated and contributed to the groundwater. The effects of this precipitation on treatment system volumes were most notable in 2014, as shown in Table 8 below. The more prolonged precipitation in 2015 was much more effective in contributing to the groundwater, as also shown in this table.

These sharp increases in flow resulted in decreases in residence time within the reactive media in these treatment systems and, therefore, reduced contact time of contaminants with the media. Even so, the treatment systems continued to remove the bulk of the contaminants. Note that by mid-January 2015, the ETPTS had been converted from a reactive media-based treatment approach to a commercial air stripper that is better able to accommodate changes in flow conditions without affecting treatment (see Appendix E Section E1.1.2.3). The SPPTS did not perform as desired, but upgrades completed in mid-2016 were successful in achieving essentially complete treatment of the nitrate in SPPTS influent by the end of the year (see Appendix E Section E1.1.2.2).

Table 8. Volume of Groundwater Treated at MSPTS, ETPTS, and SPPTS[a]

Year	MSPTS	ETPTS	SPPTS
	Estimated Annual Volume Treated (gallons)		
2000	258,000	1,633,000	64,000
2001	119,000	1,900,000	424,000
2002	53,000	1,000,000	5,600
2003	82,000	2,100,000	340,000
2004	86,000	1,500,000	230,000
2005	506,000	1,800,000	140,000
2006	430,000	675,000	251,000
2007	326,000	951,000	244,000
2008	358,000	629,000	280,000
2009	287,000	406,000	524,000
2010	420,000	1,606,000	738,000
2011	546,000	890,000	507,000
2012	461,000	622,000	498,000
2013	422,000	604,000	498,000
2014	689,000	1,298,000	591,000
2015	981,000	2,030,000	1,094,000
2016	571,000	1,799,000	459,000

Note:
[a] The estimated volume of water treated in the PLFTS is not shown because the flow data at this treatment system is not collected continuously and is not directly comparable to the other treatment system data.

6.3.3 OLF

The 2013 precipitation and subsequent flooding resulted in unusually high groundwater levels that ultimately caused portions of the periphery of the OLF to slump. The storm-water management system at the landfill was further stressed by the very wet spring in 2015. Although there has been cracking and slumping in the eastern edge of the OLF hillside over the last several years, these occurrences have been primarily outside the waste footprint, and the central portion of the OLF has remained stable. The conditions at the OLF will continue to be evaluated to identify long-term measures that will address the slope instability.

7.0 Issues, Recommendations, and Follow-Up Actions

This fourth FYR did not identify any early indicators of potential remedy problems or other issues. Key aspects of remedy implementation are timely evaluation of the data in accordance with decision rules specified in the RFLMA and reporting conditions that require an action determination and consultation with the RFMLA regulatory agencies to decide what, if any, mitigating actions should be taken and the schedule for the actions. As a result of the successful implementation of the RFLMA consultative process during this FYR period, potential issues and opportunities for optimization were identified and addressed as they were encountered. This process ensures that issues are addressed and resolved as they arise and not reserved for evaluation in the next FYR cycle.

8.0 Protectiveness Statement

The remedy at the COU is protective of human health and the environment.

Interim removal actions completed prior to the CAD/ROD included the removal of contaminated soils and sediments, decontamination and removal of equipment and buildings, construction of cover systems at the two landfills, and construction and operation of four groundwater treatment systems. A monitoring and maintenance plan is in place to assure the long-term integrity of the remedy. Routine inspections of remedy components ensure that maintenance and repairs are identified and implemented. Groundwater treatment systems continue to reduce contaminant load to surface water. Surface and groundwater monitoring provide assurance that water quality at the COU boundary is protective. Institutional controls are effective in preventing unacceptable exposures to residual contamination by prohibiting building construction, controlling intrusive activities, restricting use of groundwater and surface water, and protecting engineered remedy components. Physical controls are effective at controlling access to the COU.

Because the remedial actions at the COU are protective and the other OUs associated with the former RFP (POU and OU3) are suitable for UU/UE, the site is protective of human health and the environment.

9.0 Next Review

Contaminants at the COU are expected to remain at levels that do not allow UU/UE and will require continued remedy implementation for the foreseeable future. Thus, a fifth FYR will be required. The next FYR report will be submitted to EPA for concurrence by August 3, 2022.

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Appendix A

Site Chronology

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This appendix contains a chronology of major events that have occurred at the Rocky Flats Plant (RFP) since nuclear production operations began in 1952. The history of the RFP spans more than 65 years, of which approximately 40 years were dedicated to production in support of the U.S. nuclear weapons program, approximately 10 years to cleanup and remedy implementation, and to date, over 10 years to post-closure monitoring. This chronology provides a high-level overview of key dates in this long history and provides detail for events that occurred over the five-year period covered by this report. It is by no means all-inclusive.

Rocky Flats Plant Chronology

Date	Event
Apr 1952	Operations to produce a plutonium component for use in atomic weapons begin at the RFP.
Sep 1957	A fire in Building 771 causes extensive contamination to the building and release of some plutonium to the environment.
1967	Large-scale leaking of waste oil drums being stored on the 903 Pad occurs, contaminating the soils with plutonium, machining lubricants, and chlorinated solvents.
May 1969	A plutonium glovebox fire that started in Building 776 spread to several hundred connected gloveboxes in Building 776 and Building 777. This caused extensive damage and contamination to the buildings and release of some plutonium to the environment.
1968–1970	Some of the radiologically contaminated material is removed from the 903 Pad and Lip Area, some of the surrounding Lip Area is regraded, and much of the area is covered by an imported base coarse material. Contaminated soil becomes windborne and contaminates the area east of the 903 Pad. An asphalt cap is placed over the most contaminated area of the Pad.
Sep 1973	A tritium release is discovered in a water sample collected from Woman Creek by the Colorado Department of Health (now known as the Colorado Department of Public Health and Environment [CDPHE]). A U.S. Environmental Protection Agency (EPA) report indicates that 50–100 curies of tritium reached Great Western Reservoir, just east of the RFP.
Sep 1984	Cleanup of a 0.25-mile strip of soil on the 903 Lip Area is conducted.
Jul 1986	A Compliance Agreement is entered into between the U.S. Department of Energy (DOE), EPA, and CDPHE that defined roles and establishes milestones for major environmental operations and response actions at the RFP. These efforts identified over 2000 waste generation points and 178 Solid Waste Management Units (SWMUs) and Resource Conservation and Recovery Act/Colorado Hazardous Waste Act (RCRA/CHWA)-regulated closure sites.
Jun 1989	Federal Bureau of Investigation and EPA agents carry out a search warrant to search for evidence of alleged criminal violations of RCRA and the Federal Water Pollution Control Act.
Sep 1989	The RFP is added to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List (NPL).
Dec 1989	Nuclear production work at the RFP is halted to address environmental and safety concerns.
Jan 1990	Construction of a system to remove chemical contaminants from groundwater at the Operable Unit (OU) 1 – 881 Hillside Area begins, a designated high-priority cleanup site at the RFP. The action followed EPA and CDPHE approval of an Interim Measure/Interim Remedial Action Plan for OU1.
Jan 1991	An Interagency Agreement (IAG) between DOE, EPA, and CDPHE is signed; the IAG replaces the 1986 Compliance Agreement. The agreement outlines multiyear schedules for environmental restoration investigations and remediation.
1993	Secretary of Energy formally announces the end of nuclear production at the RFP; facility mission changes to cleanup and closure.
Nov 1994	A no action Corrective Action Decision/Record of Decision (CAD/ROD) is issued for OU16 (Low Priority Sites). This is the first OU to be officially closed out under the IAG.

Date	Event
Oct 1995	No action CAD/RODs are issued for OU11 (West Spray Field) and OU15 (Inside Building Closures).
Jul 1996	The Rocky Flats Closure Project begins, and the Rocky Flats Cleanup Agreement is signed, which supersedes the 1991 IAG. This agreement establishes the accelerated action framework, describes the goals for cleanup and closure, and defines the regulatory approach for review and approval of work to ultimately delete the RFP from the NPL. All buildings and Individual Hazardous Substance Sites are to be dispositioned through accelerated actions. OUs are reconfigured into the Industrial Area and Buffer Zone OUs. Several IAG OUs are retained because progress toward CAD/RODs for those OUs was expected.
Mar 1997	A CAD/ROD for OU1 and 881 Hillside is issued, requiring soil excavation, treatment of contaminated groundwater, and institutional controls.
June 1997	The CAD/ROD for OU3, Offsite Areas is approved; the remedy selected for OU3 is no action.
Aug 1998	Groundwater treatment operations at the Mound Site Plume Treatment System (MSPTS) commence.
Sep 1999	Groundwater treatment operations at the East Trenches Plume Treatment System (ETPTS) and Solar Ponds Plume Treatment System (SPPTS) commence.
Sep 2000	A major modification of the OU1 CAD/ROD is issued, deleting the soil excavation requirement and providing criteria for ceasing groundwater treatment and continued monitoring based on further investigation results.
Dec 2001	Rocky Flats National Wildlife Refuge Act signed.
Oct 2002	The first use of solar energy to provide power at the former RFP. A system of solar panels and storage batteries is constructed to provide power to a pump used in the groundwater collection system at the SPPTS.
Sep 2002	First FYR report is issued. Completion of this report was triggered by the completion date for the CAD/ROD for OU3. This review evaluated OU1, OU3, and several key accelerated actions at Individual Hazardous Substance Sites, as well as the installed groundwater treatment systems for the Mound Site, East Trenches, and Solar Pond Plumes and the seep at the Present Landfill (PLF).
Oct 2005	Decontamination and decommissioning of approximately 815 structures in the Industrial Area concludes with the demolition of Building 371. Physical completion of accelerated Closure Project at the former RFP. Construction of the RCRA-compliant cover on the PLF is completed; groundwater treatment operations at the Present Landfill Treatment System (PLFTS) commence. Installation of a 2-foot cover and grading of the Original Landfill (OLF) is completed.
Jun/Jul 2006	The Remedial Investigation/Feasibility Study (RI/FS) Report and Comprehensive Risk Assessment for the Central Operable Unit (COU) and the Peripheral OU (POU) are published. The RI/FS Report documented conditions after completion of all Rocky Flats Cleanup Agreement accelerated actions, evaluated three remedial alternatives for the COU, and proposed no action for the POU. The Sitewide Proposed Plan is issued for public review and comment.
Dec 2006	The Environmental Covenant, restricting use and access to the COU as stated in the CAD/ROD, is signed by DOE and CDPHE.
Sep 2006	The CAD/ROD for the COU and the POU is approved. The remedy selected for the COU is institutional and physical controls and monitoring; the remedy selected for the POU is no action.
Mar 2007	The Rocky Flats Legacy Management Agreement (RFLMA) is signed by DOE, EPA, and CDPHE. This agreement establishes the regulatory framework for implementing the remedy at the COU and ensuring it remains protective of human health and the environment.
May 2007	The POU and OU3 are deleted from the NPL. This is considered a partial deletion of the former RFP because the COU is retained on the NPL.
Jun 2007	Elevated nitrate and uranium detected in SPPTS discharge gallery prompt RFLMA consultation (see CR 2007-02).

Date	Event
Jun/Jul 2007	EPA certifies completion of cleanup and closure of the former RFP in accordance with the Rocky Flats National Wildlife Refuge Act of 2001. DOE transfers jurisdiction and control of the majority of POU lands to the U.S. Department of Interior, U.S. Fish and Wildlife Service.
Jul 2007	CDPHE approves a three-phase work plan for the OLF to address slumping and erosion issues identified during routine inspections (see CR 2008-07).
Sep 2007	Second FYR report is issued. The remedy remains protective.
Jan 2008	The PLF Monitoring and Maintenance Plan, which is adopted by reference in RFLMA, is updated to incorporate changes in inspection frequencies, completion of certain monitoring requirements, and clarification of vegetation inspection schedules and completion criteria (see CR 2007-08).
Sep 2009	The OLF Monitoring and Maintenance Plan, which is adopted by reference in RFLMA, is updated (see CR 2008-07).
Jan 2010	Effective date of changes to the Colorado Water Quality Control Commission Regulation No. 38 redefining Segment 5 of Walnut Creek to be that portion of Walnut Creek between the western and eastern boundaries of the COU. Segment 4b was redefined as that portion of Walnut Creek between the eastern boundary of the COU and Indiana St. The Recreational Use Classification of N (no primary contact use) for Segment 5 was retained.
Jul 2010	Following a 30-day public review and comment period, RFLMA Attachment 2 is modified to revise several monitoring locations (see CR 2010-04).
Mar 2011	A small-scale air stripper is installed at MSPTS. This spray-type air stripper is located in the effluent manhole and is designed to treat groundwater for VOCs following passive zero-valent iron (ZVI) treatment in underground tanks. The air stripper is powered entirely by batteries, which are recharged using solar energy.
Sep 2011	Operation of new surface water points of compliance (POCs) at Woman Creek (WOMPOC) and Walnut Creek (WALPOC) commence at the boundary of the COU. These POCs replaced former POCs at locations GS08, GS11, and GS31. A CAD/ROD amendment for the COU is signed. The primary purpose of the amendment is to clarify the description of the institutional controls pertaining to excavation, soil disturbance, and changes to engineered components.
Nov 2011	DOE and CDPHE revise the 2006 Environmental Covenant restricting use and access to the COU. The Covenant may be viewed on the Office of Legacy Management website.
Sep 2012	Third FYR report is issued. The remedy remains protective.
Feb 2013	A small-scale air stripper is installed at ETPTS. This spray-type air stripper is located in the influent manhole and is designed to treat groundwater for VOCs prior to passive ZVI treatment in underground tanks. The air stripper is powered entirely by batteries, which are recharged using solar energy. Minor modifications are made to RFLMA Attachment 2 (see CR 2012-03).
Sep 2013	The two surface water POCs at Indiana Street, GS01 and GS03, cease operation under RFLMA. This change reflects the deletion of the POU from the NPL and establishment as a National Wildlife Refuge and realignment of POCs to the COU boundary. Monitoring at GS01 and GS03 continued until 2015 under the Adaptive Management Plan. Record-setting precipitation and flooding (a 1% probability per year flood) on the Front Range of Colorado.
Oct 2013	As a result of the September 2013 flooding, slumping at the OLF results in a reportable condition (see CR 2013-02). Minor slumping had also occurred in 2007 and 2010.
Dec 2013	As a result of the September 2013 flooding, a reportable condition for the 30-day average for uranium at WALPOC is documented and persists through May 2014 (see Section 6.1.3.1).
Oct 2014	As a result of the September 2013 flooding, a reportable condition for the 12-month rolling average for uranium at WALPOC is documented (see Section 6.1.3.1 and CR 2015-01).
Dec 2014	Minor modifications are made to the PLF Monitoring & Maintenance Plan (see CR 2014-03).
Jan 2015	A commercial air-stripper is installed and begins operation at the ETPTS. This technology improvement achieves a greater reduction of VOCs in groundwater than the previous ZVI-based technology (see Section 6.1.4.3).

Date	Event
May–Sep 2015	Extended heavy precipitation over several months in the spring causes significant cracking, slumping, and movement on northwestern and eastern sides of the OLF. Immediate response actions include installing overland drain pipes and developing small drainage channels to conduct water off the cover (see CR 2015-03). Subsequent interim actions include regrading the affected areas and closing cracks (see CR 2015-06). The heavy precipitation also caused significant slumping in the North Walnut Creek basin east of the SPPTS.
Sep 2015	An extensive evaluation of water quality is finalized. *Evaluation of Water Quality Variability for Uranium and Other Selected Parameters in Walnut Creek at the Rocky Flats Site* discusses geochemical conditions resulting in mobilization of uranium in the Walnut Creek drainage.
Jun 2016	An Explanation of Significant Differences (ESD) is issued to document a significant change to the CAD/ROD approved in 2006. The change consists of removing groundwater treatment components from the MSPTS and pumping the Mound Site Plume groundwater to the ETPTS air-stripper for treatment. This improved the removal of VOCs in groundwater, eliminated the use of ZVI treatment media, and reduced the number of groundwater treatment systems in the COU from four to three.
Jul 2016	SPPTS conversion from organic media/ZVI to full-scale, interim design lagoon treatment for nitrate is completed and testing is ongoing. Evaluation of treatment technologies for uranium continues.
Sep 2016	The reconfiguration of the MSPTS is complete; combined groundwater from MSPTS and ETPTS is now treated for VOCs at the commercial air stripper at the ETPTS. Wells/piezometers are installed upgradient of the OLF to allow for long-term monitoring of groundwater levels.
Dec 2016	The ESSD reconstruction project begins. This project involved the reconstruction of an existing drainage feature designed to divert groundwater before it enters the area of the most significant slumping (see CR 2016-04). The project is completed in January 2017.
Jan 2017	The *Original Landfill Path Forward* document is published. This document evaluates long-term solutions for reducing the instability of the slopes surrounding the OLF. Two key OLF technical evaluations are included as attachments to this document: *OLF Options Report* and *OLF Geotechnical Engineering Review.*

Appendix B

Rocky Flats Legacy Management Agreement Attachment 2

Appendix C

Risk Assessment Review for COU, POU, and OU3

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C1.0 Introduction

This appendix presents the methodology for reviewing and evaluating changes to chemical and radiological risk assessment parameters that took effect during this five-year review (FYR) period and details the results of the risk evaluation. The methodology used for this evaluation is based on the methodology used for the comprehensive risk assessment (CRA) completed in 2006. The CRA included a human health and ecological risk assessment for the Central Operable Unit (COU) and the Peripheral Operable Unit (POU); a separate risk assessment was completed for Operable Unit 3 (OU3) (DOE 1996). A summary of the CRA may be found in the Third FYR report (DOE 2012), and the complete CRA is found as an appendix to the Remedial Investigation/Feasibility Study (RI/FS) Report (DOE 2006).

In accordance with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)'s FYR must provide an evaluation of changes to risk assessment factors to determine if these changes impact the risks presented by residual contamination left within the COU. The conclusions of this evaluation are then used to determine if the remedy remains protective.

Although this FYR risk evaluation is limited to risks posed by residual contamination within the COU, a separate review of the impacts of changes to risk assessment factors was conducted for the POU and OU3. The purpose of this separate review was to determine if the unlimited use/unrestricted exposure (UU/UE) designation is still valid at both OUs. The POU and OU3 were both deleted from the National Priorities List (NPL) in 2007 because they posed no significant threat to public health or the environment (Volume 72 *Federal Register* p. 29276 [72 FR 29276]).

C2.0 Central Operable Unit

In the RI/FS Report (DOE 2006), the nature and extent of residual contamination in soil and sediment were evaluated after completion of the Rocky Flats Cleanup Agreement accelerated actions. Each nature and extent of contamination evaluation identified analytes of interest (AOIs). AOIs are chemicals that have been detected at concentrations that may contribute to the risk to future receptors. The evaluation studied the extent of contaminants within the COU and POU and evaluated which chemicals remained after the completed accelerated actions. The soil AOIs identified in the RI/FS Report are presented in Table C-1.

In 2006, a comprehensive risk assessment was completed for the COU and POU to quantify the risk of residual contamination remaining after accelerated cleanup actions (DOE 2006). The CRA was conducted in accordance with the *Comprehensive Risk Assessment Work Plan and Methodology* (DOE 2004), approved by the U.S. Environmental Protection Agency (EPA) and the Colorado Department of Public Health and Environment (CDPHE). Calculations and conclusions in the CRA were based on post-remediation data; that is, data collected after the completion of all Rocky Flats Cleanup Agreement accelerated actions. To facilitate the CRA, the lands comprising the COU and POU were divided into the 12 exposure units (EUs) shown in Figure C-1. The basic methodology for conducting human health risk assessments, as described in the *Risk Assessment Guidance for Superfund* (EPA 1989), has not changed since the CRA was completed.

Table C-1. Soil Analytes of Interest Identified in the Remedial Investigation/Feasibility Study Report

Surface Soil (0–0.5 feet)	Subsurface Soil (0.5–8 feet)	Subsurface Soil (>8 feet)
Radionuclides		
Americium-241 Plutonium-239/240 Uranium-233/234 Uranium-235 Uranium-238	Americium-241 Plutonium-239/240 Uranium-235 Uranium-238	Plutonium-239/240
Metals		
Aluminum Arsenic Chromium (total) Vanadium	Chromium (total) Lead	
Volatile Organic Compounds (VOCs)		
	Tetrachloroethene	1,1,2,2-Tetrachloroethane Carbon tetrachloride Chloroform Methylene chloride Tetrachloroethene Trichloroethene
Semivolatile Organic Compounds (SVOCs)		
Benzo[*a*]pyrene Dibenz[*a,h*]anthracene	Benzo[*a*]pyrene	Benzo[*a*]pyrene
Polychlorinated Biphenyls (PCBs)		
Aroclor-1254 Aroclor-1260 2,3,7,8-TCDD		Aroclor-1260

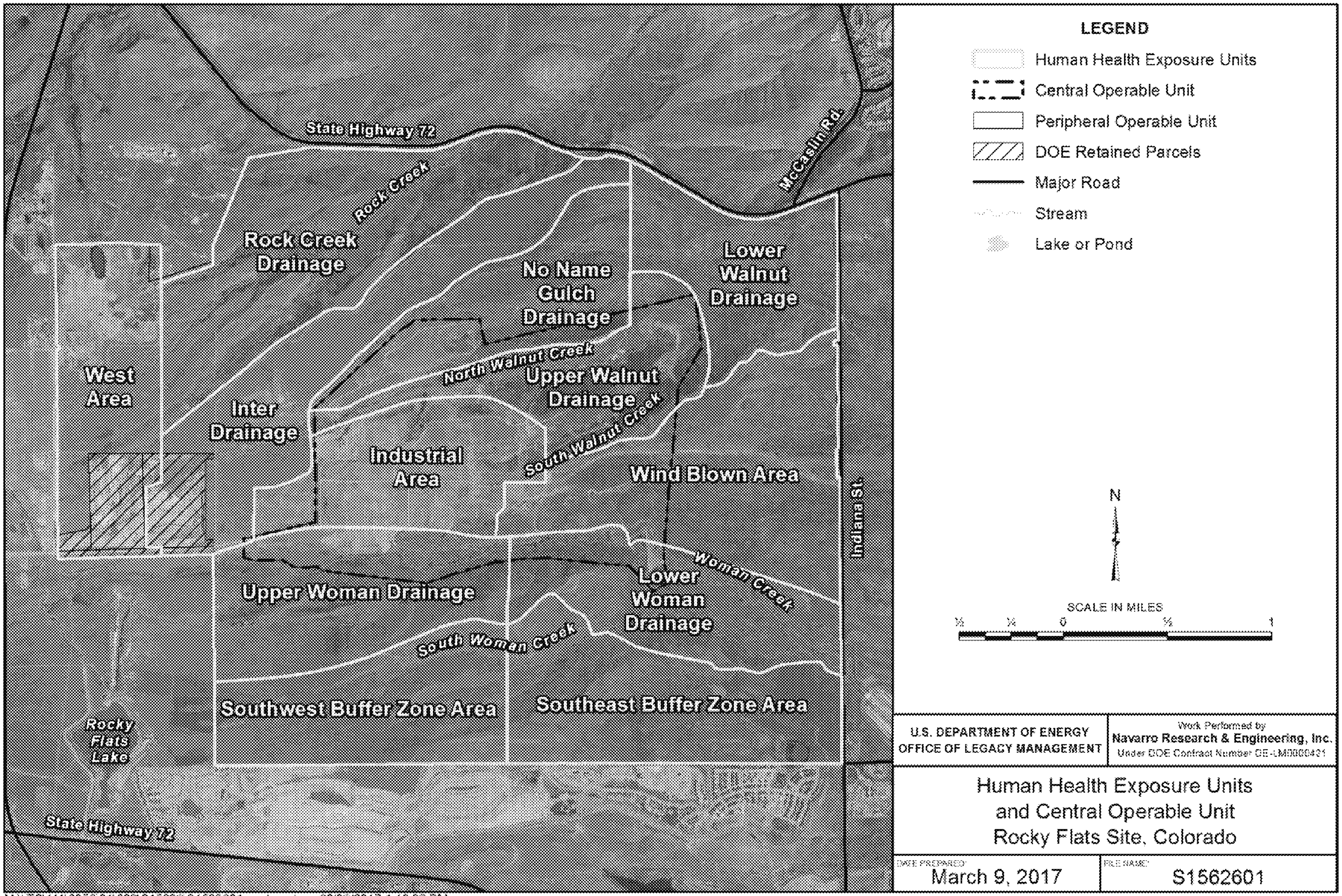

Figure C-1. Human Health EUs and COU Boundary

DRAFT

C2.1 Risk Definitions

This section presents the definitions of key risk terms used throughout this appendix.

95 percent upper confidence limit (95UCL): The statistical upper bound estimate of the mean for a set of samples and a conservative measure of the average concentration. As a general rule, EPA recommends use of the 95UCL as the exposure point concentration for soils at a site (EPA 2002).

Cancer risk: The added probability of an individual or population of developing cancer during a lifetime as a result of exposure to site contaminants. The acceptable risk range for CERCLA sites is an added risk of less than 1 in 1,000,000 (1×10^{-6}) to a maximum of 1 in 10,000 (1×10^{-4}).

Dose conversion factor (DCF): The dose to the human body associated with an exposure to a radionuclide (usually presented in millirem per picocurie [mrem/pCi] or millirem per year [mrem/year]/picocurie per gram [pCi/g]).

Hazard quotient (HQ): The ratio of the exposure level of a single substance to an acceptable noncarcinogenic toxicity value. If multiple substances are present, hazard quotients are summed in a hazard index. For CERCLA sites, the maximum acceptable hazard index is 1.0.

Maximum detected concentration (MDC): Maximum concentration detected in any soil sample for a given constituent and exposure unit.

Slope factor: An estimate of the risk of developing cancer associated with exposure to a carcinogenic or potentially carcinogenic substance.

C2.2 CRA Review Methodology

As an initial step in the comprehensive risk assessment process, residual concentrations of constituents in soil for each EU were compared to preliminary remediation goals (PRGs) developed for a wildlife refuge worker (WRW). The PRGs represent concentrations for individual chemicals that would equate to a carcinogenic risk of 1×10^{-6} or a noncarcinogenic HQ of 0.1 based on the exposure assumptions for the WRW. The 2006 CRA used a HQ of 0.1 as an initial, conservative screening level; a HQ of 1.0 is the maximum permissible limit. The PRGs were developed using toxicity data that were current at the time of the CRA and were developed for exposures to both surface and subsurface soils. PRGs for subsurface soils are higher than those for surface soils, as it was assumed that the exposure frequency would be much lower (20 days per year compared to 230 days per year). The MDC for each detected constituent at each EU was compared to its respective PRG. If the MDC was less than the PRG, the constituent was eliminated from further consideration. If the MDC exceeded the PRG, the 95UCL of the mean for that constituent was compared to the PRG. If the 95UCL was less than the PRG, the constituent was eliminated from further consideration. If the 95UCL exceeded the PRG, the constituent was further evaluated based on frequency of detection, comparison to background concentrations, and professional judgement. Constituents passing through these remaining screening criteria were identified as contaminants of concern (COCs) for each EU (Table C-2) and were further evaluated in the CRA. (Note that the analytes of interest screening process and CRA EU-specific COC screening process were somewhat different and produced different results.) In the 2006 CRA, COCs were only identified for surface soils. All constituents in subsurface soils were eliminated by the 95UCL screen and no quantitative risks were calculated.

Table C-2. Surface Soil COCs Identified for Each EU in the CRA

Constituent	Exposure Unit											
	Industrial Area EU	Upper Woman Drainage EU	Wind Blown EU	No Name Gulch EU	Upper Walnut Drainage EU	Lower Woman Drainage EU	Rock Creek EU	Lower Walnut Drainage EU	Inter Drainage EU	West Area EU	Southwest Buffer Zone Area EU	Southeast Buffer Zone Area EU
Part of COU	•	•	•	•	•	•						
Part of POU	•	•	•	•	•	•	•	•	•	•	•	•
Arsenic	X	-	X	-	-	-	-	-	-	-	-	-
Vanadium	-	-	-	X	-	-	-	-	-	-	-	-
2,3,7,8-TCDD	-	X	-	-	-	-	-	-	-	-	-	-
Benzo[*a*]pyrene	X	X	-	-	X	-	-	-	-	-	-	-
Plutonium-239/240	-	-	X	-	-	-	-	-	-	-	-	-

Abbreviations:
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-*p*-dioxin
X = constituent was designated a COC in the 2006 CRA
\- = constituent was not designated a COC in the 2006 CRA

C2.3 FYR Risk Evaluation

The following sections discuss the review methodology and results from this FYR risk evaluation for the COU. The sections have been separated into chemical and radionuclide constituents because the methodologies for these evaluations were slightly different.

C2.3.1 Chemical Constituent Review Methodology

Because the first two steps of the COC screening process in the CRA relied on a comparison of residual soil concentrations with the WRW PRGs, any subsequent changes to exposure assumptions or toxicity values used to calculate the PRGs could change the outcome of the screening process. For this FYR risk evaluation, a methodology similar to that described above for the CRA was applied to determine the impact of changes to risk assessment parameters for surface soils. Figure C-2 presents the screening methodology. In lieu of recalculating site-specific PRGs for a WRW, this FYR risk evaluation utilized the EPA regional screening levels (RSLs) for industrial soil as a proxy for revised WRW PRGs (EPA 2016a). The RSLs incorporate current toxicity data and methodologies for the same exposure pathways of concern for the WRW. The default exposure assumptions for the industrial soil scenario are very similar to those used for the WRW for surface soils. Table C-3 compares the key assumptions used in RSL and site-specific PRG calculations. Where exposure factors are not the same, those used by EPA tend to be more conservative (i.e., assume a greater degree of exposure). Therefore, it was determined that the EPA industrial soil RSLs were an acceptable screening tool to represent updated surface soil WRW PRGs (referred to as "updated WRW RSLs" for the remainder of this appendix).

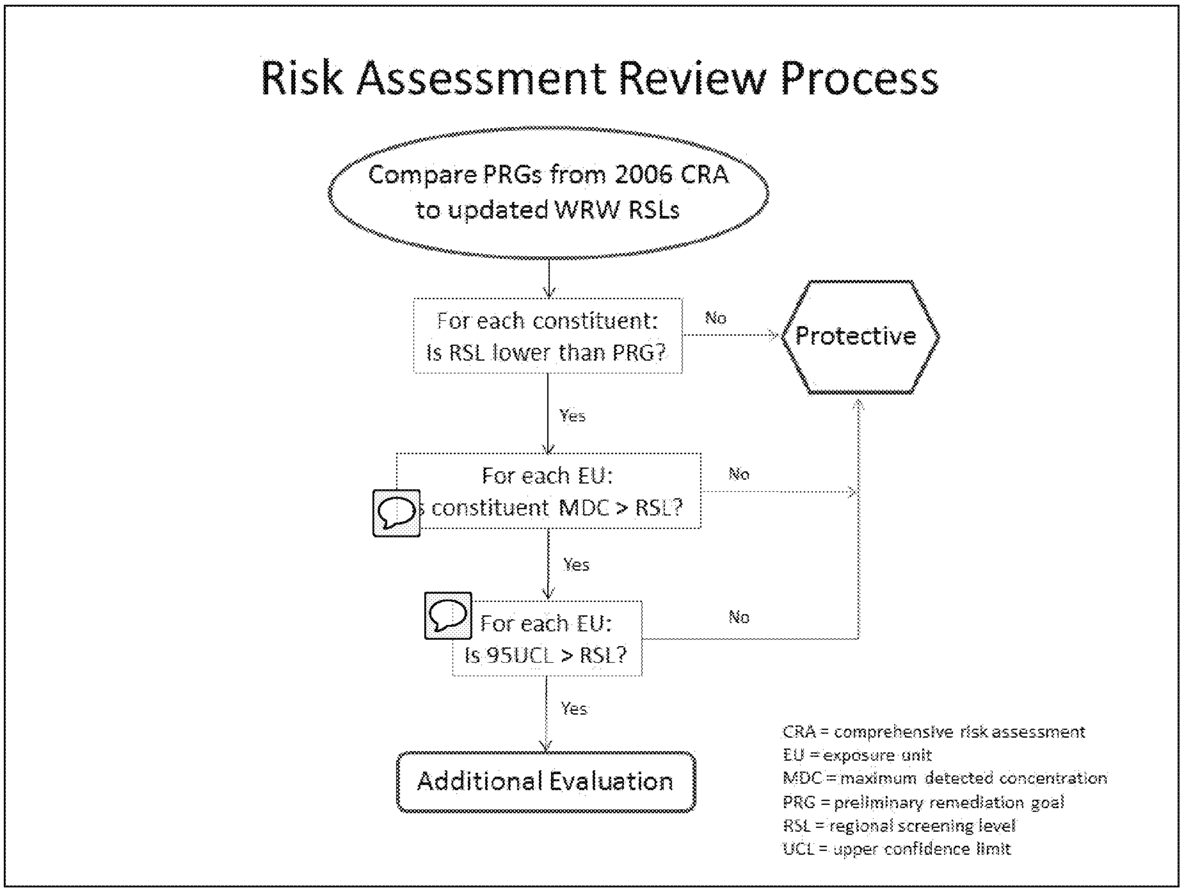

Figure C-2. Risk Assessment Review Process

Table C-3. Comparison of Key Exposure Assumptions for RSLs and PRGs

Exposure Factor (units)	EPA RSL Default Value	WRW PRG Assumption
Frequency of exposure (days/year)	250	Surface soils, 230 Subsurface soils, 20
Exposure duration (years)	25	18.7
Exposure time (hours/day)	8	8
Soil ingestion rate (milligrams/day)	100	100
Adult body weight (kilograms)	80	70
Skin surface area (square centimeters)	3527	3300

The complete list of surface soil PRGs developed for the comprehensive risk assessment was compared to the updated WRW RSLs list (EPA 2016). Of the more than 200 original PRGs that were evaluated, slightly more than half of the PRGs were higher than (i.e., greater than) the updated RSLs. The vast majority of the lower RSL values were for organic chemicals of which many are volatile organic compounds (VOCs). EPA has recently finalized guidance on vapor intrusion (EPA 2015) and as a result has updated information on many VOCs included in the RSL tables. Additionally, the EPA approach to evaluating risks for the inhalation pathway was finalized in 2009. The methodology used in the CRA reflects older guidance for estimating exposures for this pathway. It is likely that a combination of these factors explain why such a large number of the PRGs are higher than current RSLs. Decreases for most constituents were within an order of magnitude, but RSLs for a few constituents are several orders of magnitude lower than PRGs (e.g., cyclohexane).

Where PRGs were lower than current RSLs, it was assumed that results of the original screening process are still valid. Where RSLs were lower than PRGs, a rescreening of the EU statistical data was performed. EPA RSLs that were lower than PRGs were compared to data presented in the CRA for each EU. The analytical data (MDCs and 95UCL values) used in this FYR are the same data used in the 2006 comprehensive risk assessment; no new data were collected to support this FYR. The MDCs and 95UCLs used in the surface soil screening were compared to the RSLs. If 95UCL data were not already tabulated, a 95UCL was calculated from statistical data provided in the CRA. If MDCs or 95UCLs were lower than the current RSLs, constituents were eliminated from further consideration. All other constituents were retained for further evaluation. Table C-4 presents the results of the chemical screening process by EU; Table C-5 summarizes the screening process by constituent.

Table C-4. Surface Soil Chemical Constituent Screening Results by EU

Constituent	Industrial Area EU	Upper Woman Drainage EU	Wind Blown EU	No Name Gulch EU	Upper Walnut Drainage EU	Lower Woman Drainage EU	Rock Creek EU	Lower Walnut Drainage EU	Inter Drainage EU	West Area EU	Southwest Buffer Zone Area EU	Southeast Buffer Zone Area EU
Arsenic	X	-	X	-	-	-	-	-	-	-	-	-
Vanadium	-	-	-	X	-	-	-	-	-	-	-	-
2,3,7,8-TCDD	-	X	-	-	-	-	-	-	-	-	-	-
Aroclor-1254	X	-	X	X	-	-	-	-	-	-	-	-
Aroclor-1260	X	-	-	-	-	-	-	-	-	-	-	-
Benzo[*a*]anthracene	X	X	-	-	-	-	-	-	-	-	-	-
Benzo[*a*]pyrene	X	X	X	X	X	-	-	-	-	-	-	-
Benzo[*b*]fluoranthene	X	X	-	-	-	-	-	-	-	-	-	-
Cobalt	X	-	-	-	-	-	-	-	-	-	-	-
Dibenz[*a,h*]anthracene	X	X	-	-	-	-	-	-	-	-	-	-
Indeno[1,2,3-*cd*]pyrene	-	X	-	-	-	-	-	-	-	-	-	-
Lead and compounds	-	-	-	X	-	-	-	-	-	-	-	-
Mercury (elemental)	X	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	X		-	-	-	-	-	-	-	-	-
N-Nitroso-di-*n*-propylamine	-	-	X	-	-	-	-	-	-	-	-	-
Uranium (soluble salts)[a]	X	X	-	-		-	-	-	-	-	-	-

Notes:
[a] The revised risk-based screening level for uranium was calculated using the oral reference dose recommended in EPA's December 2016 memorandum (EPA 2016b). This screening level is lower than that contained in EPA's current RSLs.
Shaded boxes indicate 95UCL > WRW RSL.
Arsenic and vanadium were included in this table because these constituents were identified as COCs in the CRA and their 95UCL exceeds their PRG.

Abbreviations:
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-*p*-dioxin
X = constituent MDC > WRW RSL
\- = constituent MDC or 95UCL < WRW RSL

Table C-5. Surface Soil Chemical Constituent Screening Results by Constituent

All Constituents with PRGs[a]	Constituents Where EPA RSL < PRG[a]	Constituents Where EPA RSL < PRG (any EU)[a]	Constituents Where MDC > EPA RSL (any EU)[a]
Acenaphthene Acenapthylene Acetone Acrolein Acrylonitrile Alachlor Aldicarb Aldicarb sulfone Aldicarb sulfoxide Aldrin Aluminum Ammonia Anthracene Antimony (metallic) Aroclor 1016 Aroclor 1221 Aroclor 1232 Aroclor 1242 Aroclor 1248 Aroclor 1254 Aroclor 1260 Arsenic, Inorganic Atrazine Barium Benzene Benzidine Benz[*a*]anthracene Benzo[*a*]pyrene Benzo[*b*]fluoranthene Benzo[*g,h,*i]perylene Benzo[*k*]fluoranthene Benzoic acid Benzyl alcohol Beryllium and compounds Bis(2-chloroethyl)ether Bis(2-chloro-1-methylethyl) ether Bis(2-ethylhexyl)phthalate Boron and borates only Bromodichloromethane Bromoform Bromomethane 2-Butanone (methyl ethyl ketone) Butyl benzyl phthalate Cadmium (diet) Carbazole Carbofuran Carbon disulfide Carbon tetrachloride Chlordane-alpha Chlordane-beta Chlordane-gamma 4-Chloroaniline Chlorobenzene Ethyl chloride (chloroethane) Chloroform	1,1,1-Trichloroethane 1,1,2,2-Tetrachloroethane 1,1,2-Trichloro-1,2,2-trifluoroethane 1,1,2-Trichloroethane 1,1-Dichloroethane, 1,2,3-Trichloropropane 1,2,4-Trichlorobenzene 1,2-Dibromo-3-chloropropane 1,2-Dichlorobenzene 1,2-Dichloroethane 1,2-Dichloropropane 1,2-Diphenylhydrazine 1,4-Dioxane 2,4,6-Trichlorophenol 2,4-Dimethylphenol 2,4-Dinitrophenol 2,4-Dinitrotoluene 2,6-Dinitrotoluene 2,3,7,8-TCDD, 2-Butanone (methyl ethyl ketone) 2-Chloronaphthalene (beta-) 2-Methylnaphthalene 3,3'-Dichlorobenzidine 4,6-Dinitro-o-cresol 4-Chloroaniline 4-methyl-2-pentanone (methyl isobutyl ketone) 4-Nitroaniline, Acetone Acrolein Acrylonitrile Aroclor 1221 Aroclor 1232 Aroclor 1242 Aroclor 1248 Aroclor 1254 Aroclor 1260 Atrazine Benzene Benzidine Benz[*a*]anthracene Benzo[*a*]pyrene Benzo[*b*]fluoranthene Benzo[*k*]fluoranthene Benzyl alcohol Bis(2-chloroethyl)ether Bis(2-ethylhexyl)phthalate Bromodichloromethane Bromoform Bromomethane Butyl benzyl phthalate Carbon disulfide Carbon tetrachloride Chlordane-gamma Chlorobenzene	1,1,1-Trichloroethane 1,1,2,2-Tetrachloroethane 1,1,2-Trichloro-1,2,2-trifluoroethane 1,2,3-Trichloropropane 1,2,4-Trichlorobenzene 1,2-Dichloropropane 2,4,6-Trichlorophenol 2,4-Dimethylphenol 2,4-Dinitrophenol 2,3,7,8-TCDD, 2-Butanone (methyl ethyl ketone) 2-Methylnaphthalene, 4-methyl-2-pentanone (methyl isobutyl ketone) Acetone Aroclor 1242 Aroclor 1248 Aroclor 1254 Aroclor 1260 Benzene Benz[*a*]anthracene Benzo[*a*]pyrene Benzo[*b*]fluoranthene Benzo[*k*]fluoranthene Benzyl alcohol Bis(2-ethylhexyl)phthalate Bromodichloromethane Bromomethane Butyl benzyl phthalate Carbon disulfide Carbon tetrachloride Chlorobenzene Chloroform Chloromethane (methyl chloride) Chrysene Cobalt DDD DDE, p,p'- DDT Dibenz[*a,h*]anthracene Dibenzofuran Dieldrin Dimethylphthalate di-N-Octyl phthalate thylbenzene ~Fluorene Hexachlorobenzene Hexachlorobutadiene Indeno[1,2,3-*cd*]pyrene Isophorone Lead and compounds Lithium Mercury (elemental) Naphthalene	2,3,7,8-TCDD, Aroclor 1254 Aroclor 1260 Benz[*a*]anthracene Benzo[*a*]pyrene Benzo[*b*]fluoranthene Cobalt Dibenz[*a,h*]anthracene Indeno[1,2,3-*cd*]pyrene Lead and compounds Mercury (elemental) Naphthalene Nitroso-di-*n*-propylamine, N- Uranium (soluble salts)[b]

Table C-5. Surface Soil Chemical Constituent Screening Results by Constituent (continued)

All Constituents with PRGs[a]	Constituents Where EPA RSL < PRG[a]	Constituents Where EPA RSL < PRG (any EU)[a]	Constituents Where MDC > EPA RSL (any EU)[a]
Chloromethane (methyl chloride) 4-Chloro-3-methylphenol (Cresol, p-chloro-m-) 2-Chloronaphthalene (beta-) Chlorophenol, 2- Chlorpyrifos Chromium(III), insoluble salts Chromium(VI) Chrysene Cobalt Copper Cyanide (CN^-) Cyclohexane DDD DDE, p,p'- DDT Dalapon Demeton Dibenz[*a,h*]anthracene Dibenzofuran Dibromochloromethane 1,2-Dibromo-3-chloropropane Dibutyl phthalate Dicamba Dichlorobenzene, 1,2- Dichlorobenzene, 1,3- Dichlorobenzene, 1,4- Dichlorobenzidine, 3,3'- Dichlorodifluoromethane Dichloroethane, 1,1- Dichloroethane, 1,2- Dichloroethylene, 1,1- Dichloroethene, 1,2- (total) Dichlorophenol, 2,4- Dichlorophenoxy acetic acid, 2,4- Dichlorophenoxy)butyric acid, 4-(2,4- Dichloropropane, 1,2- Dichloropropane, 1,3- Dichloropropene, *cis*-1,3- Dichloropropene, *trans*-1,3- Dieldrin Diethyl ether (ethyl ether) Di(2-ethylhexyl)adipate Diethyl phthalate Dimethoate Dimethylphenol, 2,4- Dimethylphthalate Dinitro-o-cresol, 4,6- Dinitrophenol, 2,4- Dinitrotoluene, 2,4- Dinitrotoluene, 2,6- di-N-Octyl phthalate Dinoseb Dioxane, 1,4- TCDD, 2,3,7,8- Diphenylhydrazine, 1,2-	Chloroform Chloromethane (methyl chloride) Chlorpyrifos Chrysene Cobalt Cyanide (CN^-) Cyclohexane DDD DDE, p,p'- DDT Di(2-ethylhexyl)adipate Dibenz[*a,h*]anthracene Dibenzofuran Dibromochloromethane Dichlorodifluoromethane Dieldrin Dimethoate Dimethylphthalate di-N-Octyl phthalate Ethyl acetate Ethylbenzene Fluorene Heptachlor Hexachlorobenzene Hexachlorobutadiene Hexachlorocyclohexane, alpha- Hexachlorocyclohexane, beta- Hexachlorocyclohexane, gamma- (Lindane) Hexachlorocyclohexane, technical Hexachlorocyclopentadiene Hexachlorodibenzo-*p*-dioxin Hexachloroethane HxCDD, 1,2,3,6,7,8- HxCDD, 1,2,3,7,8,9- Indeno[1,2,3-*cd*]pyrene Isophorone Lead and compounds Lithium Mercury (elemental) Methyl methacrylate Methyl *tert*-butyl ether (MTBE) Mirex Naphthalene Nitrobenzene Nitrosodiethylamine, N- Nitrosodimethylamine, N- Nitroso-di-N-butylamine, N- Nitroso-di-*n*-propylamine, N- Nitrosodiphenylamine, N- Nitrosopyrrolidine, N- Pentachlorophenol p-Nitrotoluene, Simazine	Nitroso-di-*n*-propylamine, N- Pentachlorophenol Styrene Thallium (soluble salts) Uranium (soluble salts)[b] Xylenes	

Table C-5. Surface Soil Chemical Constituent Screening Results by Constituent (continued)

All Constituents with PRGs[a]	Constituents Where EPA RSL < PRG[a]	Constituents Where EPA RSL < PRG (any EU)[a]	Constituents Where MDC > EPA RSL (any EU)[a]
Diquat Endosulfan I Endosulfan II Endosulfan sulfate Endosulfan (technical) Endrin Endrin aldehyde Endrin ketone Ethyl acetate Ethylbenzene Ethylene dibromide (Dibromoethane, 1,2-) Fluoranthene Fluorene Fluorine (soluble fluoride) Glyphosate Guthion (azinphos-methyl) Heptachlor Heptachlor epoxide Hexachlorobenzene Hexachlorobutadiene Hexachlorocyclohexane, alpha- Hexachlorocyclohexane, beta- Hexachlorocyclohexane, gamma- (Lindane) Hexachlorocyclohexane, delta- Hexachlorocyclohexane, technical Hexachlorocyclopentadiene Hexachlorodibenzo-*p*-dioxin HxCDD, 1,2,3,6,7,8- HxCDD, 1,2,3,7,8,9- Hexachloroethane Indeno[1,2,3-*cd*]pyrene Iron Isobutyl alcohol Isophorone Isopropylbenzene (cumene) Lead and compounds Lithium Manganese (diet) Mercury (elemental) Methoxychlor MCPA MCPP Methylene chloride Methyl methacrylate Methylnaphthalene, 2- Methyl isobutyl ketone (4-methyl-2-pentanone) 2-Methylphenol (cresol, *o*-) 4-Methylphenol (Cresol, *p*-) Methyl *tert*-butyl ether (MTBE) Mirex Molybdenum	Styrene Thallium (soluble salts) Toxaphene Uranium (soluble salts)[b] Vinyl acetate Vinyl chloride Xylene, *m*- Xylene, *o*- Xylene, *p*- Xylenes		

Table C-5. Surface Soil Chemical Constituent Screening Results by Constituent (continued)

All Constituents with PRGs[a]	Constituents Where EPA RSL < PRG[a]	Constituents Where EPA RSL < PRG (any EU)[a]	Constituents Where MDC > EPA RSL (any EU)[a]
Naphthalene Nickel soluble salts Nitrate Nitrite Nitroaniline, 2- Nitroaniline, 4- Nitrobenzene Nitrophenol, 4- Nitroso-di-N-butylamine, N- Nitrosodiethylamine, N- Nitrosodimethylamine, N- Nitrosodiphenylamine, N- Nitroso-di-*n*-propylamine, N- Nitrosopyrrolidine, N- Nitrotoluene, p- Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) Oxamyl Parathion Pentachlorobenzene Pentachlorophenol Phenanthrene Phenol Picloram Pyrene Selenium Silver Simazine Strontium, stable Styrene Sulfide Tetrachlorobenzene, 1,2,4,5- Tetrachloroethane, 1,1,1,2- Tetrachloroethane, 1,1,2,2- Tetrachloroethylene Tetrachlorophenol, 2,3,4,6- Thallium (soluble salts) Tin Titanium Toluene Toxaphene Trichlorobenzene, 1,2,4- Trichloroethane, 1,1,1- Trichloroethane, 1,1,2- Trichloroethylene Trichlorofluoromethane Trichlorophenol, 2,4,5- Trichlorophenol, 2,4,6- Trichlorophenoxypropionic acid, -2,4,5 Trichloropropane, 1,2,3- Trichloro-1,2,2- Trifluoroethane, 1,1,2- Trinitrotoluene, 2,4,6- Uranium (soluble salts)[b] Vanadium and compounds Vinyl acetate Vinyl chloride Xylene, *p*-			

Table C-5. Surface Soil Chemical Constituent Screening Results by Constituent (continued)

All Constituents with PRGs[a]	Constituents Where EPA RSL < PRG[a]	Constituents Where EPA RSL < PRG (any EU)[a]	Constituents Where MDC > EPA RSL (any EU)[a]
Xylene, *m*- Xylene, *o*- Xylenes Zinc and compounds			

Notes:

[a] The first column lists all constituents for which WRW PRGs were developed. The constituents are arranged in the same order as they were in the CRA methodology document where the PRGs were developed (DOE 2004). The second column lists all constituents where the May 2016 EPA RSLs were lower than the WRW PRGs. The constituents are arranged in the order used in the PRG screening tables that were included in the CRA for each EU. That same order is used for subsequent columns. The third column includes all constituents that were carried through the screening process for any EU. The last column contains all constituents with an MDC that exceeded an EPA RSL. Note that arsenic and vanadium are not carried past the first column in this table because the EPA RSLs are greater than the WRW PRGs and rescreening isn't required.

[b] The rev[illegible] risk-based screening level for uranium was calculated using the oral reference dose recommended in EPA's [illegible]mber 2016 memorandum (EPA 2016). This screening level is lower than that contained in EPA's current RSLs.

Because no COCs were identified in the CRA for subsurface soils and because the reevaluation of surface soil data discussed above indicated that the CRA process was sound in identifying COCs, a more targeted approach was taken in this FYR to answer Question B with regard to subsurface soils. An abbreviated PRG list was used for subsurface soil screening based on the results of the surface soil screening process. This included all constituents for which any surface soil MDC exceeded the surface soil PRG (constituents listed in Table C-4 and last column in Table C-5); tetrachloroethene was also added to this list as it was identified as a subsurface analyte of interest in the RI/FS (Table C-1). The constituents evaluated along with screening results are listed in Table C-6. The current WRW RSLs were multiplied by 11.5 to obtain current estimates of subsurface WRW PRGs. The screening with this smaller set of PRGs proceeded in the same manner as the surface soil FYR evaluation described above.

Table C-6. Subsurface Soil Chemical Constituent Screening Results by EU

Constituent	Industrial Area EU	Upper Woman Drainage EU	Wind Blown EU	No Name Gulch EU	Upper Walnut Drainage EU	Lower Woman Drainage EU	Rock Creek EU	Lower Walnut Drainage EU	Inter Drainage EU	West Area EU	Southwest Buffer Zone Area EU	Southeast Buffer Zone Area EU
2,3,7,8-TCDD	-	-	-	-	-	-	-	-	-	-	-	-
Aroclor-1254	X	-	-	-	-	-	-	-	-	-	-	-
Aroclor-1260	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	X	-	-	-	-	-	-	-	-	-	-	-
Benzo[*a*]anthracene	-	X	-	-	-	-	-	-	-	-	-	-
Benzo[*a*]pyrene	X	X	X	-	-	-	-	-	-	-	-	-
Benzo[*b*]fluoranthene	-	X	-	-	-	-	-	-	-	-	-	-
Cobalt	-	X	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	X	-	-	-	-	-	-	-	-	-	-	-
Indeno[1,2,3-*cd*]pyrene	-	-	-	-	-	-	-	-	-	-	-	-
Lead and compounds	-	-	-	-	-	-	-	-	-	-	-	-
Mercury (elemental)	-	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	X	-	-	-	-	-	-	-	-	-	-	-
N-Nitroso-di-*n*-propylamine	-	-	-	-	-	-	-	-	-	-	-	-
Tetrachloroethene	-	-	-	-	-	-	-	-	-	-	-	-
Vanadium	-	-	-	-	-	-	-	-	-	-	-	-
Uranium (soluble salts)	X	-	-	-	-	-	-	-	-	-	-	-

Notes:
Arsenic and vanadium were included in this table because these constituents were identified as COCs in the CRA and their 95UCL exceeds their WRW PRG.

Abbreviations:
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-*p*-dioxin
- = MDC < EPA RSL
X = MDC > EPA RSL

C2.3.2 Chemical Constituent Evaluation Results

Surface Soils. As was the case in the original comprehensive risk assessment screening process, nearly all constituents were eliminated in this FYR risk evaluation based on the MDC comparison screen. Despite the lower EPA RSLs, the MDCs were typically much lower than those screening values. Very few constituents were retained by the RSL screen that were not also retained by the PRG screen. Among these is uranium, for which EPA has recently recommended a much lower toxicity value (EPA 2016). Most constituents passing the RSL screen were subsequently eliminated based on the 95UCL comparison or following additional evaluation (e.g., frequency of detection <5%). Of the constituents evaluated in this FYR evaluation screening process, only four constituents passed through the 95UCL screen. These are summarized in Table C-7.

Table C-7. Chemical Constituents and EUs where 95UCL Exceeds Current Screening Level

	Exposure Unit											
Constituent	Industrial Area EU	Upper Woman Drainage EU	Wind Blown EU	No Name Gulch EU	Upper Walnut Drainage EU	Lower Woman Drainage EU	Rock Creek EU	Lower Walnut Drainage EU	Inter Drainage EU	West Area EU	Southwest Buffer Zone Area EU	Southeast Buffer Zone Area EU
Arsenic	X	-	X	-	-	-	-	-	-	-	-	-
Vanadium	-	-	-		-	-	-	-	-	-	-	-
2,3,7,8-TCDD		X	-	-	-	-	-	-	-	-	-	-
Benzo[*a*]pyrene	X	X	-	X	X	-	-	-	-	-	-	-
Dibenz[*a,h*]anthracene	-	X	-	-	-	-	-	-	-	-	-	-

Notes:
Shaded boxes differ from the CRA results.

Abbreviations:
2,3,7,8-TCDD = 2,3,7,8-tetrachlorodibenzo-*p*-dioxin
- = constituent not considered a COC in CRA.
X = constituent would be considered a COC based on CRA screening methodology

As in the original comprehensive risk assessment, dioxin was identified as a COC for the Upper Woman Drainage EU and benzo[*a*]pyrene as a COC for the Industrial Area EU, Upper Woman Drainage EU, and the Upper Walnut Drainage EU. Based on the rescreening process, benzo[*a*]pyrene would also be considered a COC for the No Name Gulch EU, with concentrations slightly above the current RSL. The rescreening process also confirmed that arsenic is still considered a COC for the Industrial Area EU and Wind Blown EU based on current RSL concentrations; estimated risk levels associated with residual arsenic would be similar to that in the CRA. The arsenic 95UCL for all the other EUs also exceeded the PRG (and the current RSL) but arsenic was eliminated as a COC for those EUs in the CRA based on subsequent screens. Based on the current vanadium RSL, vanadium would not be a COC. The vanadium PRG is based on a lower toxicity value than is currently being used by EPA; however, vanadium is still undergoing study and this value could change in the future. As in the CRA, dibenz[*a,h*]anthracene did pass through the 95UCL screen for the Upper Woman Drainage EU; however, the frequency of detection was less than 5% for this constituent, and it was eliminated on that basis. For the most part, the rescreening process confirmed the results of the CRA for surface soils.

Subsurface Soils. The MDCs for a number of constituents exceeded the updated WRW RSLs. However, all constituents dropped out based on the 95UCL screen, and the reevaluation confirmed that there are no subsurface COCs.

The vapor intrusion pathway was identified in the CRA as a potentially complete pathway for VOCs in subsurface soils, including those at depths greater than 8 feet. Most of the AOIs identified for subsurface soils in the RI/FS Report are VOCs (Table C-1). EPA has finalized guidance for evaluating the vapor intrusion pathway (EPA 2015) and provided guidance for evaluating this pathway in five-year reviews (EPA 2012b). Updated toxicity data are also available for some VOCs that are identified as AOIs at subsurface depths greater than 8 feet (e.g., tetrachloroethene and trichloroethene). However, institutional controls are in place at the COU that eliminate the vapor intrusion pathway by prohibiting the construction of habitable structures. Remedial action objectives (RAOs) and cleanup goals remain valid and are not affected by updated guidance and toxicity data as long as institutional controls remain in place.

In addition to the toxicity values discussed above, EPA is reviewing the toxicity of two COCs for the COU, arsenic and benzo[*a*]pyrene. The arsenic study suggests that current methods of estimating risks from arsenic due to soil ingestion likely overestimate actual risks. The EPA study of benzo[*a*]pyrene (EPA 2014) is not yet completed, and results cannot be cited at this time. Changes in slope factors may be forthcoming, but are not yet available. None of these additional studies affect the protectiveness of the remedy.

C2.3.3 Radiological Constituent Review Methodology

As various scientific radiological organizations and communities (e.g., Center for Radiation Protection Knowledge, International Commission on Radiological Protection [ICRP], and EPA Federal Guidance Reports [FGRs]) gain greater knowledge of the effects of ionizing radiation on humans, changes are made to their supporting and guidance documents that are then used in radiological risk and dose calculation tools, such as the online EPA PRG calculator and the RESRAD dose model.

Information from the current EPA PRG calculator was used in this FYR risk evaluation to determine if the risks from radionuclides to the WRW in the COU remain within the acceptable CERCLA risk range (i.e., 1×10^{-4} to 1×10^{-6}). Information in the online PRG calculator incorporates the numerous changes to toxicity factors that have occurred since 2006, including revisions specific to plutonium and uranium. In fact, 18 revisions have been made to the PRG calculator since 2001. In September 2014, a significant revision was adopted that follows EPA recommendations concerning the use of exposure parameters from the EPA *Exposure Factors Handbook* (EPA 2011). New slope factors for radionuclides have been programmed into the calculator that were derived following Federal Guidance Reports 12 and 13 using the updated isotope list from ICRP107. The cancer slope factors used by the PRG calculator are provided by the Center for Radiation Protection Knowledge. Examples of some of the slope factors used in the CRA (2006) compared to those found in the current EPA PRG calculator (2017) are shown in Table C-8.

Information from the current EPA PRG calculator was used in this FYR evaluation to determine if the risk from radionuclides to the WRW in the COU remains within the acceptable CERCLA risk range. To perform the FYR radiological risk evaluation, the input parameters used in the 2006 CRA for the WRW were used along with information from the current EPA PRG calculator to obtain updated PRG values that represent a 1×10^{-6} level of risk. These updated PRG values were then compared to the WRW PRG values from the 2006 CRA. For completeness, this FYR considered $^{239/240}$Pu (the only radionuclide COC identified in the 2006 CRA), ^{241}Am, ^{234}U, ^{235}U, and ^{238}U. The americium and uranium isotopes represent the other primary radionuclides associated with RFP historical operations. This methodology does not require input of site-specific analytical data because PRGs represent concentrations based on a target risk level rather than a calculated risk due to measured concentrations. As such, no new soil analytical data were collected for this FYR risk evaluation. Changes in PRG values (from

2006 to 2017) are the result of changes made to either the calculators and how they function (e.g., formulas used in the calculations process have been modified/updated) or the scientific data that the calculators use to compute risk (e.g., isotopic cancer slope factors or DCFs), or a combination of both.

Table C-8.Comparison of Slope Factors for Various Pathways

Isotope	1994	2006	2017
	Adult Ingestion		
^{241}Am	2.40×10^{-10}	9.1×10^{-11}	9.1×10^{-11}
^{239}Pu	2.30×10^{-10}	1.21×10^{-10}	1.21×10^{-10}
^{234}U	1.60×10^{-11}	5.11×10^{-11}	5.11×10^{-11}
^{235}U	1.60×10^{-11}	4.92×10^{-11}	4.92×10^{-11}
^{238}U	1.60×10^{-11}	4.66×10^{-11}	4.66×10^{-11}
	Adult Inhalation		
^{241}Am	3.20×10^{-8}	2.81×10^{-8}	3.77×10^{-8}
^{239}Pu	3.80×10^{-8}	3.33×10^{-8}	5.55×10^{-8}
^{234}U	2.60×10^{-8}	1.14×10^{-8}	2.78×10^{-8}
^{235}U	2.50×10^{-8}	1.01×10^{-8}	2.50×10^{-8}
^{238}U	2.40×10^{-8}	9.32×10^{-9}	2.36×10^{-8}
	Adult External Exposure		
^{241}Am	4.90×10^{-9}	2.76×10^{-8}	2.77×10^{-8}
^{239}Pu	1.70×10^{-11}	2.00×10^{-10}	2.09×10^{-10}
^{234}U	3.00×10^{-11}	2.52×10^{-10}	2.53×10^{-10}
^{235}U	2.40×10^{-11}	5.18×10^{-7}	5.51×10^{-7}
^{238}U	2.10×10^{-11}	4.99×10^{-11}	1.24×10^{-10}

Limitations on Use of the EPA PRG Calculator. During the review/recalculation process, it was noted that the current online PRG calculator requires additional information that was not used in the 2006 PRG calculations and, thus, not available for input. While the EPA PRG calculator contains default values for all of these additional inputs, it was determined that the use of default values would create an entirely new scenario, distinct from that evaluated in 2006. The resulting comparison of these updated PRGs calculated by the PRG calculator to the 2006 PRGs would not be appropriate or meaningful. To address this issue, updated PRG values were calculated using a Microsoft Excel spreadsheet (or Excel calculator) created to run the various applicable formulas found in the current EPA PRG calculator. Significant effort was taken to accurately recalculate PRG values using the 2006 and earlier data sets, by checking the results of the Excel spreadsheet against known values. Risk slope factors from the online 2017 EPA PRG calculator, as well as decay constants of the isotopes being used in the calculation, are used by the Excel calculator to calculate current (2017) PRG values. Calculations performed in the Excel spreadsheet did not take into account progeny from the parent isotopes, similar to what occurs in the EPA PRG calculator. Verification of the Excel spreadsheet calculator was performed using available data inputs from the 2006 CRA taken from the 2004 CRA methodology document (DOE 2004), the 2002 radionuclide soil action levels used during accelerated remedial actions in the COU (DOE, EPA and CDPHE 2002), and the programmatic PRGs calculated in 1994 for the OU3 baseline risk assessment (DOE 1994).

C2.3.4 Radionuclide Constituent Evaluation Results

Table C-9 contains the PRG comparison results for the WRW in the COU. As shown in the table, the 2017 PRG values for each radionuclide are less conservative (i.e., larger) than the PRGs calculated in 2006. Therefore, even though changes have occurred to various toxicity factors and other risk input since 2006, the remedy in the COU remains protective.

Table C-9. PRG Comparison for WRW in the COU (pCi/g at 10^{-6} risk level)

Isotope	2006 CRA PRG	2017 PRG
^{241}Am	7.69	8.81
^{239}Pu	9.78	11.85
^{234}U	25.31	29.96
^{235}U	1.05	1.06
^{238}U	29.33	34.38

C2.3.5 Radiological Dose Assessment Review

In addition to human health risk calculations performed in the comprehensive risk assessment, a radiation dose assessment for exposure to residual radionuclide contamination in surface soil and subsurface soil was also completed. The purpose of the dose assessment was to demonstrate compliance with the annual dose limits in Colorado Radiation Control Regulations (Volume 6 *Code of Colorado Regulations* Regulation 1007-1, Part 4 [6 CCR 1007-1, Part 4]), which were identified as Applicable Relevant and Appropriate Requirements (ARARs) in the Corrective Action Document/Record of Decision (CAD/ROD) (DOE 2006). For radiological sites that do not allow for unrestricted use, as is the case for the COU, Colorado regulations require that institutional controls be in place that reasonably ensure that the total effective dose equivalent from residual radioactivity at the site does not exceed 25 mrem/year (6 CCR 1007-4.61.2).

RESRAD-ONSITE is a pathway analysis computer code that calculates radiation doses and cancer risks to a critical population group and can be used to derive cleanup criteria for radioactively contaminated soils. Since 2002, eight revisions have been made to RESRAD-ONSITE (RESRAD). In 2014, RESRAD was revised to allow dose conversion factor database and software capability for ICRP107. In 2016, RESRAD was revised to provide options to choose between the ICRP38 radionuclide decay database and the ICRP107 radionuclide decay database; ICRP38 supports the use of either ICRP26/30- or ICRP60/72-based dose coefficients, and ICRP107 supports the use of ICRP60-based dose coefficients from DCFPAK 3.02.

Changes to ICRP Versions. Within the RESRAD-ONSITE Computer Code (Revision 7.2, July 20, 2017), both DCFs and slope factors are used. For the verification calculations performed in 2017, the program was first set to use ICRP38 for radionuclide transformations. This configuration defaults to ICRP72 (selectable from adult to infant) for the internal dose library, ICRP60 for the external dose library, and FGR13 morbidity risk factors (Figure C-3). The

ICRP38 configuration best approximates the older 2006 (Revision 6.3) version of the calculator that was used in 2006, as ICRP38 was replaced by ICRP107 in 2008 in the software program. Then the calculator was set to use ICRP107 for radionuclide transformations. This configuration defaults to U.S. Department of Energy (DOE) STD-1196-2001 Reference Person (selectable from adult to infant) for the internal dose library, DCFPAK 3.02 for the external dose library, and DCFPAK 3.02 morbidity risk factors (Figure C-4). *Oak Ridge National Laboratory, Calculation of Slope Factors and Dose Coefficients, September 2014* (https://epa-prgs.ornl.gov/radionuclides/SlopesandDosesFinal.pdf) provides detailed information regarding the development of the risk factors and does coefficients used in the current RESRAD-ONSITE software program. Both the ICRP38 and ICRP107 versions of the RESRAD-ONSITE calculator were run (using the old data), to provide an understanding of the revisions to the RESRAD-ONSITE calculator, based on the results of the calculator runs.

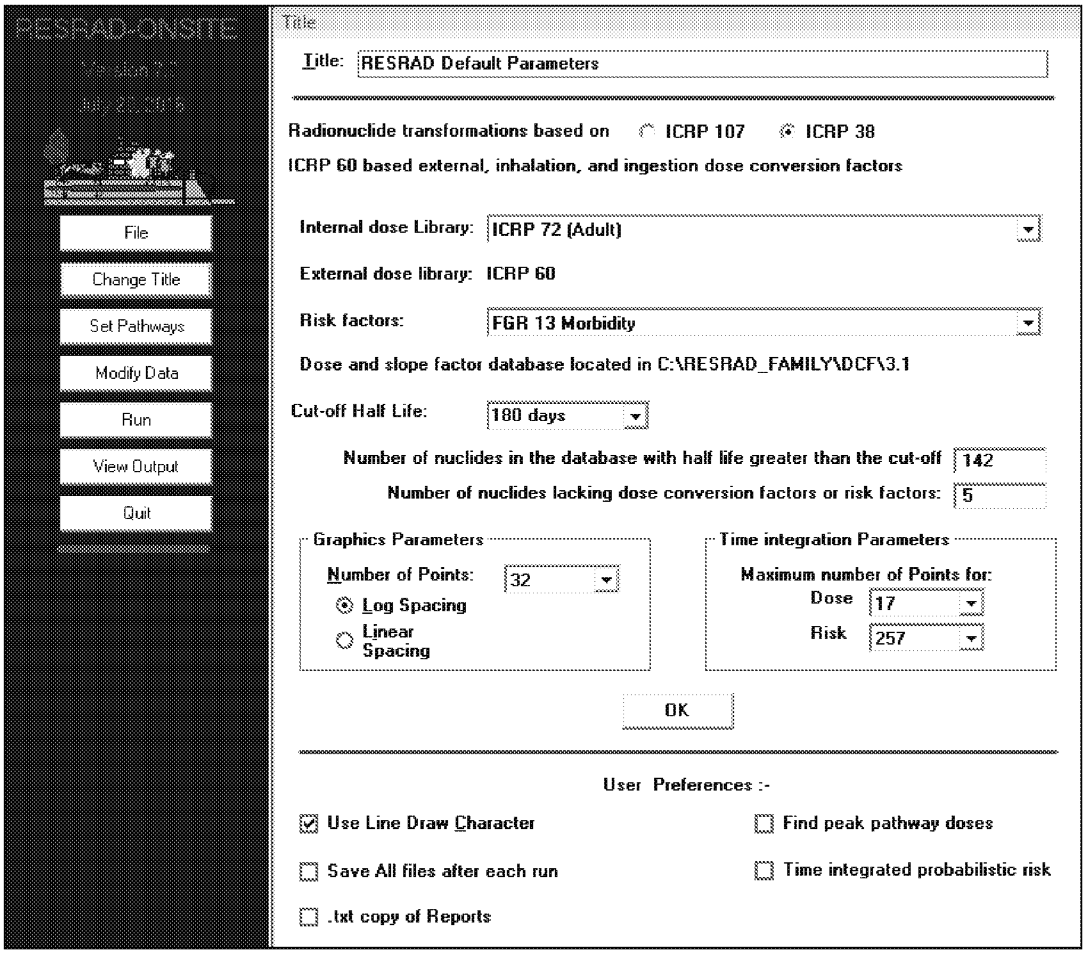

Figure C-3. RESRAD-ONSITE Title Screen, ICRP 38

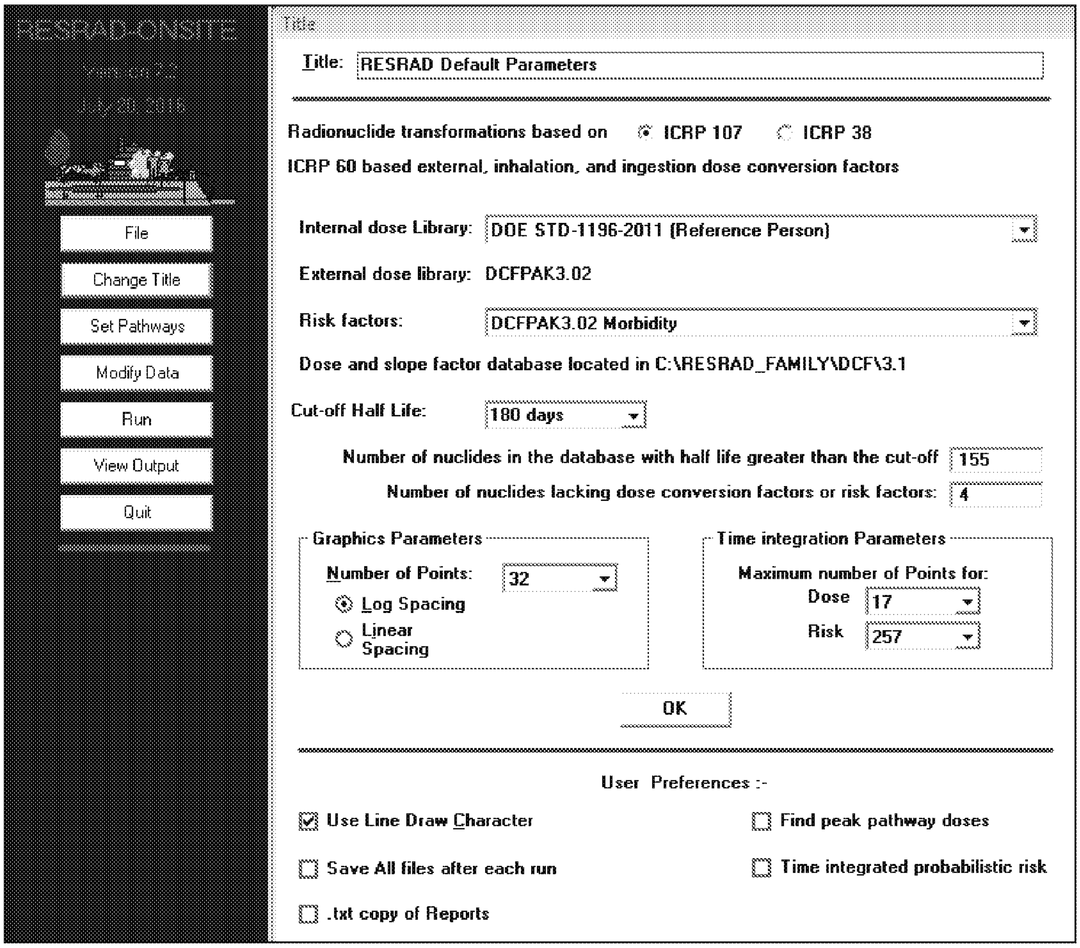

Figure C-4. RESRAD-ONSITE Title Screen, ICRP 107

Changes to Dose Conversion Factors. RESRAD-ONSITE dose conversion factors were evaluated for changes between the 2006 and 2017 software program (versions 6.3 and 7.2 and ICRP38 and ICRP107, respectively). Only the key isotopes (those input in the calculator for the modeling runs performed in both 2006 and 2017, ^{241}Am, ^{239}Pu, ^{234}U, ^{235}U, and ^{238}U) were evaluated, as progeny isotope DCF values would likely follow suit of the parent isotope.

As shown in Tables C-10 and C-11, most DCF values for the inhalation and ingestion pathways changed between the 2006 and 2017 calculator versions for the parent and progeny isotopes. Shaded cells in the tables are the key isotopes (^{239}Pu, ^{241}Am) that were input into the calculators. Nonshaded table cells are isotopes that are introduced by the RESRAD-ONSITE calculator as a result of progeny ingrowth during the 1000-year evaluation time period. While those added isotopes add little value to the comparison aspect of the review, they represent the various DCFs for the radionuclides that in-grow over the 1000-year evaluation time period.

Table C-10. RESRAD Dose Conversion Factors (2006 and 2017, Am and Pu, Adult)

DCFs for Inhalation (mrem/pCi)					
Menu Code	**Parameter**	**2006 ICRP72 Value**	**2017 ICRP38 Value**	**2017 ICRP107 Value**	**Parameter Name**
B-1	^{227}Ac+D	6.724×10^{0}	2.104×10^{0}	6.714×10^{-1}	DCF2(1)
	^{241}Am	1.600×10^{-1}	3.552×10^{-1}	3.630×10^{-1}	DCF2(2)
	^{237}Np+D	5.400×10^{-1}	1.850×10^{-1}	1.869×10^{-1}	DCF2(3)
	^{231}Pa	1.280×10^{0}	5.180×10^{-1}	8.769×10^{-1}	DCF2(4)
	^{239}Pu	1.900×10^{-1}	4.440×10^{-1}	4.477×10^{-1}	DCF2(5)
	^{229}Th+D	2.169×10^{0}	9.481×10^{-1}	9.865×10^{-1}	DCF2(6)
	^{233}U	1.350×10^{-1}	3.552×10^{-2}	3.811×10^{-2}	DCF2(7)
	^{235}U+D	1.100×10^{-2}	3.145×10^{-2}	3.378×10^{-2}	DCF2(8)
DCFs for Ingestion (mrem/pCi)					
Menu Code	**Parameter**	**2006 ICRP72 Value**	**2017 ICRP38 Value**	**2017 ICRP107 Value**	**Parameter Name**
D-1	^{227}Ac+D	1.480×10^{-2}	4.473×10^{-3}	2.308×10^{-3}	DCF3(1)
	^{241}Am	7.400×10^{-4}	7.400×10^{-4}	8.806×10^{-4}	DCF3(2)
	^{237}Np+D	4.444×10^{-3}	4.102×10^{-4}	4.674×10^{-4}	DCF3(3)
	^{231}Pa	1.060×10^{-2}	2.627×10^{-3}	2.068×10^{-3}	DCF3(4)
	^{239}Pu	9.300×10^{-4}	9.250×10^{-4}	1.066×10^{-3}	DCF3(5)
	^{229}Th+D	4.027×10^{-3}	2.269×10^{-3}	3.329×10^{-3}	DCF3(6)
	^{233}U	2.890×10^{-4}	1.887×10^{-4}	2.227×10^{-4}	DCF3(7)
	^{235}U+D	1.713×10^{-4}	1.752×10^{-4}	2.048×10^{-4}	DCF3(8)

Nonshaded table cells are isotopes that are introduced by the RESRAD-ONSITE calculator as a result of progeny ingrowth during the 1000-year evaluation time period.

Table C-11. RESRAD Dose Conversion Factors (2006 and 2017, U, Adult)

DCFs for Inhalation (mrem/pCi)					
Menu Code	**Parameter**	**2006 ICRP72 Value**	**2017 ICRP38 Value**	**2017 ICRP107 Value**	**Parameter Name**
B-1	^{227}Ac+D	6.724×10^{0}	2.104×10^{0}	6.714×10^{-1}	DCF2(1)
	^{231}Pa	1.280×10^{0}	5.180×10^{-1}	8.769×10^{-1}	DCF2(2)
	^{210}Pb+D	2.320×10^{-2}	3.697×10^{-2}	4.017×10^{-2}	DCF2(3)
	^{226}Ra+D	8.594×10^{-3}	3.526×10^{-2}	3.823×10^{-2}	DCF2(4)
	^{230}Th	3.260×10^{-1}	3.700×10^{-1}	3.848×10^{-1}	DCF2(5)
	^{234}U	1.300×10^{-2}	3.478×10^{-2}	3.737×10^{-2}	DCF2(6)
	^{235}U+D	1.100×10^{-2}	3.145×10^{-2}	3.378×10^{-2}	DCF2(7)
	^{238}U	1.060×10^{-2}	2.960×10^{-2}	3.212×10^{-2}	DCF2(8)
	^{238}U+D	1.063×10^{-2}	2.963×10^{-2}	3.215×10^{-2}	DCF2(9)
DCFs for Ingestion (mrem/pCi)					
Menu Code	**Parameter**	**2006 ICRP72 Value**	**2017 ICRP38 Value**	**2017 ICRP107 Value**	**Parameter Name**
D-1	^{227}Ac+D	1.480×10^{-2}	4.473×10^{-3}	2.308×10^{-3}	DCF3(1)
	^{231}Pa	1.060×10^{-2}	2.627×10^{-3}	2.068×10^{-3}	DCF3(2)
	^{210}Pb+D	7.276×10^{-3}	6.998×10^{-3}	1.026×10^{-2}	DCF3(3)
	^{226}Ra+D	1.321×10^{-3}	1.037×10^{-3}	1.677×10^{-3}	DCF3(4)
	^{230}Th	5.480×10^{-4}	7.770×10^{-4}	9.361×10^{-4}	DCF3(5)
	^{234}U	1.800×10^{-4}	1.813×10^{-4}	2.150×10^{-4}	DCF3(6)
	^{235}U+D	1.713×10^{-4}	1.752×10^{-4}	2.048×10^{-4}	DCF3(7)
	^{238}U	1.700×10^{-4}	1.665×10^{-4}	1.939×10^{-4}	DCF3(8)
	^{238}U+D	1.837×10^{-4}	1.791×10^{-4}	2.112×10^{-4}	DCF3(9)

Nonshaded table cells are isotopes that are introduced by the RESRAD-ONSITE calculator as a result of progeny ingrowth during the 1000-year evaluation time period.

As a result of changes made between the 2006 and 2017 RESRAD calculator versions, with regard to being able to select a child's age in the 2017 calculator version (e.g., infant, 1 year old, 5 years old, 10 years old, 15 years old), there were significant differences in the results of the RESRAD-ONSITE runs performed during the review, selecting different ages for each run. Therefore, a comparison of DCFs for non-adults was not performed and is not presented in the tables above.

Notes

For information not available/provided in the 2006 RESRAD result data sheets, the reviewer used 2017 RESRAD-ONSITE calculator default values.

For Child Surface Soil Am and Pu, Solar Ponds Revision 7.2, the RESRAD-ONSITE internal dose library allows for the selection of an age range of the child's age (unlike 2006) for use in a given scenario (five non-adult choices of age). The reviewer used "Age 1" as the scenario input for the 2017 recalculation. The "Age" input section is very sensitive to the calculation result, so results varied significantly (11.5–0.778 mrem) as age selection was varied. The "older" ages (10 and 15) result in relatively smaller doses at time zero (the time of the largest dose to the individual). The 2006 Child scenarios reviewed identified "child" as the selection, and not "infant." The reviewer followed suit and elected not to use the "infant" option for the Age input selection.

C2.3.6 Dose Assessment Review Results

The dose assessment completed in 2006 used version 6.3 of the RESRAD computer code to calculate radiation doses to a scenario-driven critical population within the COU. The input parameters used in 2006 were entered into the most recent version of RESRAD (version 7.2) to calculate dose. The results of these 2006 calculations were compared to the current version of RESRAD (version 7.2) results, allowing the reviewer the ability to compare past RESRAD calculation results to current results. This comparison can then be used to better understand if changes in the results are occurring, and if occurring, to what magnitude. Note that a new dose was not calculated for the COU in this evaluation. No new sample data were collected to support this fourth FYR dose evaluation. Instead, the same input parameters and analytical data values used in 2006 were entered into the most recent RESRAD version to determine the relative impact of changes to the computer code.

In order to understand the relative impact to dose resulting from the numerous changes to input parameters and the computer model that have occurred since 2006, a range of exposure scenarios and associated analytical data evaluated in the 2006 RESRAD (version 6.3) dose assessment was entered into the current RESRAD model (version 7.2). Four existing 2006 scenarios were selected to review and recalculate total dose: (1) resident adult exposure to Pu-239 and Am in subsurface soil in the Ash Pits East area, (2) resident child exposure to Pu-239 and Am in surface soil at the Solar Evaporation Ponds, (3) WRW exposure to uranium in subsurface soil at the Wind Blown area, and (4) WRW exposure to uranium in surface soil at the Wind Blown area. This semi-random selection of scenarios was slightly bias-based to include a mix of radionuclides (^{241}Am, ^{239}Pu, ^{234}U, ^{235}U, and ^{238}U), both adult and child scenarios, and three different locations with surface and subsurface impacts/potential impacts in different OUs (COU and POU). Table C-12 presents the 2006 RESRAD scenario calculation results for the four scenarios, the 2017 RESRAD-ONSITE scenario calculation results using ICRP 38, and the 2017 RESRAD-ONSITE results using ICRP107.

A comparison of the RESRAD version 6.3 dose results to the RESRAD version 7.2 dose results indicates little change in total dose. Each of the 2006 scenarios evaluated yielded similar results, suggesting that the changes in total dose for all scenarios and locations evaluated in 2006 would be negligible using the current RESRAD model version. This simply means that the changes to RESRAD since 2006 have not resulted in major impacts to dose calculated by the model. That is, the dose calculated using RESRAD version 6.3 is nearly the same as the dose calculated using RESRAD version 7.2, given the same site-specific input parameters used in 2006. Therefore, because the dose assessment from 2006 indicated that the lands within the COU are in compliance with the dose criteria ARAR from the CAD/ROD with a total dose much less than 25 mrem/year, a recalculation of dose using the most updated version of RESRAD would yield the same results, and the ARAR would still be met. As a result, this FYR dose assessment evaluation concludes that the dose criteria ARAR continues to be met and the remedy in the COU remains protective.

Table C-12. RESRAD Scenario Calculation Results (2006 and 2017)

RESRAD Scenario Identification	Maximum Total Dose (mrem/year)
2006 Resident Adult Subsurface Soil Am and Pu Ash Pits East	8.918E-04
2017 Resident Adult Subsurface Soil Am and Pu Ash Pits East (ICRP38)	8.986E-04
2017 Resident Adult Subsurface Soil Am and Pu Ash Pits East (ICRP107)	9.893E-04
2006 Resident Child Surface Soil Am and Pu Solar Ponds	1.499E+00
2017 Resident Child Surface Soil Am and Pu Solar Ponds (ICRP38)	1.351E+00
2017 Resident Child Surface Soil Am and Pu Solar Ponds (ICRP107)	1.361E+00
2006 WRW Subsurface Wind Blown U	8.499E-03
2017 WRW Subsurface Wind Blown U (ICRP38)	8.682E-03
2017 WRW Subsurface Wind Blown U (ICRP107)	9.259E-03
2006 WRW Surface Wind Blown U	8.029E-02
2017 WRW Surface Wind Blown U (ICRP38)	8.226E-02
2017 WRW Surface Wind Blown U (ICRP107)	8.818E-02

C3.0 POU

The chemical and radiological risks associated with the POU were evaluated as part of the 2006 comprehensive risk assessment (DOE 2006). A radiological dose assessment using the RESRAD computer code was also completed. The POU and OU3 (discussed in Section C4.0) were determined to be suitable for UU/UE and were deleted from the NPL in 2007 (72 FR 29276). Because conditions at these two OUs were determined to meet the criteria for UU/UE, a FYR of these OUs is not required. However, the continued applicability of UU/UE for these OUs was reviewed in light of potential changes to toxicity factors and other risk-related information since the original UU/UE determinations were made. The conclusions from these reviews are discussed in this section for the POU and in Section C4.0 for OU3.

C3.1 Chemical Constituents Evaluation

The chemical review of the UU/UE criteria for the POU utilized a similar approach as the COU chemical risk evaluation. The rural resident soil action levels calculated in 2002 were compared to the EPA 2016 residential RSL table values (most recent values available). All 2016 RSLs that were lower than the 2002 values (i.e., were more conservative) were retained for comparison against residual POU surface soil concentrations from the 2006 CRA dataset (Table C-13). All residual surface soil concentrations correspond to levels within or below the acceptable risk range (1×10^{-4} to 1×10^{-6}) based on the updated residential RSLs. It is therefore confirmed that the POU is still suitable for UU/UE.

Table C-13. 2016 Residential RSLs and POU Surface Soil Concentrations

Constituent	2016 Residential RSLs (µg/kg)		Range of Concentrations Detected in POU Surface Soils (µg/kg)
Risk Level	1×10^{-4}	1×10^{-6}	
2,6-Dinitrotoluene	36,000	360	170–550
Benzo[*a*]anthracene	16,000	160	170–550
Benzo[*a*]pyrene	1600	16	170–1000
Benzo[*b*]fluoranthene	16,000	160	170–550
Bis(2-chloroethyl)ether	23,000	230	170–550
Bis(2-chloroisopropyl)ether	8600	86	170–550
Dibenz[*a,h*]anthracene	1600	16	170–550
Hexachlorobenzene	21,000	210	170–550
Indeno[1,2,3-*cd*]pyrene	16,000	160	170–550
N-Nitroso-di-*n*-propylamine	7800	78	170–550
Aroclor-1254	3,800[a]	120[a]	80–260
Pentachlorophenol	100,000	1000	850–2650

Note:
[a] Upper screening level based on HQ = 1.

Abbreviation:
µg/kg = micrograms per kilogram

C3.2 Radiological Constituents Evaluation

The radiological review of the UU/UE criteria for the POU utilized the same approach used for the COU radiological risk evaluation. The 2017 EPA online calculator was used to generate site-specific PRGs for the POU based on a residential scenario that were then compared to the rural resident PRGs calculated in 2002, assuming the same data inputs. As with each of the risk reviews completed for this FYR report, no new soil analytical data were collected. The site-specific input parameters for the POU risk review were taken from the 2002 Radionuclide Soil Action Levels report (DOE, EPA, and CDPHE 2002). It was necessary to use the input parameters from this report because, unlike the 2006 CRA, the 2002 report included evaluation of a rural resident scenario, which is appropriate for the UU/UE evaluation.

Table C-14 presents the results of the POU UU/UE review. Although the only COCs identified in the POU were Pu-239/240 and Am-241, the U isotopes were included in order to be consistent with the COU and OU3 reviews. As shown in the table, the 2017 PRGs for Am-241, Pu-239, U-234, and U-238 at a risk level of 1×10^{-6} are lower than those calculated in 2002 at the same risk level. This means that the overall risk from these radionuclides has increased as a result of changes in toxicity factors and/or formulas adopted since 2002. The changes in the PRGs for Pu-239 are significant across the risk range (10^{-4} to 10^{-6}), which indicates that the risk associated with Pu-239 for the rural resident has increased since 2002. To provide perspective, the MDC of Pu-239 in the POU in 2006 was approximately 20 pCi/g (DOE, EPA, CDPHE 2006). This equates to a risk between 1×10^{-4} and 1×10^{-5} when compared to the 2017 PRG values. While this risk is closer to the higher end of the risk range (i.e., less protective), it is still within the acceptable risk range. Based on this radiological review, the POU continues to meet the criteria for UU/UE.

Table C-14. PRGs for POU Rural Resident Exposure Scenario (pCi/g)

Isotope	2002			2017 (using ICRP 107)		
Risk Level	1×10^{-4}	1×10^{-5}	1×10^{-6}	1×10^{-4}	1×10^{-5}	1×10^{-6}
^{241}Am	7.0E01	7.0E00	1.0E00	5.35E01	5.35E00	5.35E-01
^{239}Pu	12.8E01	1.3E01	1.0E00	4.35E01	4.35E00	4.35E-01
^{234}U	3.6E01	4.0E00	4.0E-01	1.23E01	1.23E00	1.23E-01
^{235}U	1.1E01	1.0E00	1.0E-01	1.14E01	1.14E00	1.14E-01
^{238}U	4.0E01	4.0E00	4.0E-01	1.36E01	1.36E00	1.36E-01

C4.0 OU3

A Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation report and baseline risk assessment (BRA) were completed for OU3 in June 1996 (DOE 1996). This report identified the COCs in OU3 as Pu-239/240 and Am-241 in surface soils and Pu-239/240 in surface sediments within the Great Western Reservoir. Although COCs were only identified for surface soil and sediment in OU3, the Facility Investigation/Remedial Investigation gathered and considered a substantial amount of surface water, groundwater, and air data. The BRA included evaluation of residential and recreational exposure scenarios and concluded that conditions in OU3 were within the acceptable risk range for protection of human health. The CAD/ROD for OU3 was published in June 1997 and selected no action as the remedy (DOE, EPA, and CDPHE 1997).

C4.1 Radiological Constituents Review Methodology

As with the COU and POU risk evaluations, the 2017 EPA online calculator was used as a basis to generate site-specific PRGs for OU3 that could then be compared to the PRGs from 1994, assuming the same calculator data inputs. No new data were collected for this FYR risk evaluation for OU3. As with the other OUs, in order to perform PRG calculations using the site-specific data from 1994, calculations were performed using Microsoft Excel (instead of the EPA PRG online calculator). The EPA PRG equations used in the online calculator were written into an Excel spreadsheet calculator and then validated for accuracy. For OU3, the residential scenario was used in the Excel calculator, using values provided in the 1994 *Programmatic Risk Based Preliminary Remediation Goals* document (DOE 1994).

Figures C-5 and C-6 present the equations used to calculate the PRG for exposure to soil using a residential scenario. As evidenced in these figures and in the resulting comparison of calculated PRGs described later in this section, there have been several changes to input parameters and equations used in the risk assessment since 1994. This presented a challenge when entering the 1994 input parameters into the present-day PRG calculator because some input parameters were not considered in 1994 that are now required input into the EPA PRG calculator.

$$PPRG_1 = \frac{TR \times AT \times 365\ days/year}{EF \times \left[(SFi \times IRa \times ED \times \frac{1}{BW} \times \frac{1}{PEF}) + (SFo \times 10^{-6}\ kg/mg \times IF) \right]}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_1$	Risk-based PPRG for surface soil based on residential use (mg/kg)	-
TR	target excess lifetime cancer risk (unitless)	10^{-6}
AT	averaging time (years)	70 years
EF	exposure frequency (days/year)	350 days/year
SFi	inhalation cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
IRa	daily inhalation rate (m^3/day)	20 m^3/day
ED	exposure duration (years)	30 years
BW	adult body weight (kg)	70 kg
PEF	particulate emission factor (m^3/kg)	$4.63 \times 10^9\ m^3/kg$
SFo	oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
IF	age-adjusted soil ingestion factor (mg-yr/kg-day)	114 mg-yr/kg-day

Figure C-5. 1994 Equation for Resident Soil PRG

Resident Soil

- incidental ingestion of soil

$$PRG_{res\text{-}soil\text{-}ing}(pCi/g) = \frac{TR \times t_{res}(year) \times \lambda\left(\frac{1}{year}\right)}{\left(1-e^{-\lambda t_{res}}\right) \times SF_s\left(\frac{risk}{pCi}\right) \times IFS_{res\text{-}adj}(1{,}120{,}000\ mg) \times \left(\frac{g}{1000\ mg}\right)}$$

where:

$$IFS_{res\text{-}adj}(1{,}120{,}000\ mg) = \left(\begin{array}{l} \left(EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}c}(6\ years) \times IRS_{res\text{-}c}\left(\frac{200\ mg}{day}\right)\right) + \\ \left(EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}a}(20\ years) \times IRS_{res\text{-}a}\left(\frac{100\ mg}{day}\right)\right) \end{array} \right)$$

- inhalation of particulates emitted from soil

$$PRG_{res\text{-}soil\text{-}inh}(pCi/g) = \frac{TR \times t_{res}(year) \times \lambda\left(\frac{1}{year}\right)}{\left(1-e^{-\lambda t_{res}}\right) \times SF_i\left(\frac{risk}{pCi}\right) \times IFA_{res\text{-}adj}\left(161{,}000\ m^3\right) \times \frac{1}{PEF\left(\frac{m^3}{kg}\right)} \times \left(\frac{1000\ g}{kg}\right)}$$

where:

$$IFA_{res\text{-}adj}\left(161{,}000\ m^3\right) = \left(\begin{array}{l} \left(EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}c}(6\ years) \times ET_{res\text{-}c}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times IRA_{res\text{-}c}\left(\frac{10\ m^3}{day}\right)\right) + \\ \left(EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}a}(20\ years) \times ET_{res\text{-}a}\left(\frac{24\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times IRA_{res\text{-}a}\left(\frac{20\ m^3}{day}\right)\right) \end{array} \right)$$

- external exposure to ionizing radiation

$$PRG_{res\text{-}soil\text{-}ext}(pCi/g) = \frac{TR \times t_{res}(year) \times \lambda\left(\frac{1}{year}\right)}{\begin{array}{c} \left(1-e^{-\lambda t_{res}}\right) \times SF_{ext\text{-}sv}\left(\frac{risk/year}{pCi/g}\right) \times EF_{res}\left(\frac{350\ days}{year}\right) \times \left(\frac{1\ year}{365\ days}\right) \times ED_{res}(26\ years) \times ACF_{ext\text{-}sv} \times \\ \left[\left(ET_{res\text{-}o}\left(\frac{1.752\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times GSF_{o\text{-}ext\text{-}sv}(1.0)\right) + \left(ET_{res\text{-}i}\left(\frac{16.416\ hours}{day}\right) \times \left(\frac{1\ day}{24\ hours}\right) \times GSF_i(0.4) \times GSF_b(1.0)\right)\right] \end{array}}$$

Figure C-6. 2017 Equation for Resident Soil PRG

- consumption of fruits and vegetables back-calculated to soil

$$PRG_{res\text{-}soil\text{-}produce\text{-}ing\text{-}tot}\,(pCi/g) = \frac{1}{\left(\sum_{i=1}^{n} \frac{1}{PRG_{res\text{-}soil\text{-}produce\text{-}ing}\,(pCi/g)_i}\right)}$$

where:

n = total number of produce items included

and:

$$PRG_{res\text{-}soil\text{-}produce\text{-}ing}\,(pCi/g) = \frac{PRG_{res\text{-}produce\text{-}ing}\,(pCi/g)}{\left(R_{upv} + R_{es}\right)} \times \left(\frac{t_{res}\,(year) \times \lambda\left(\frac{1}{year}\right)}{\left(1 - e^{-\lambda t_{res}}\right)}\right)$$

where:

$$R_{upv} = Bv_{wet} \; ; \; R_{es} = MLF_{produce}$$

- consumption of fruits and vegetables.

$$PRG_{res\text{-}produce\text{-}ing}(pCi/g) = \frac{TR}{SF_f\left(\frac{risk}{pCi}\right) \times IF_{res\text{-}adj}\,(g) \times CF_{res\text{-}produce}\,(1)}$$

where:

$$IF_{res\text{-}adj}\,(g) = \begin{pmatrix} \left(EF_{res\text{-}c}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}c}\,(6\ years) \times IR_{res\text{-}c}\left(\frac{g}{day}\right)\right) + \\ \left(EF_{res\text{-}a}\left(\frac{350\ days}{year}\right) \times ED_{res\text{-}a}\,(20\ years) \times IR_{res\text{-}a}\left(\frac{g}{day}\right)\right) \end{pmatrix}$$

- total

$$PRG_{res\text{-}soil\text{-}tot}\,(pCi/g) = \frac{1}{\frac{1}{PRG_{res\text{-}soil\text{-}ing}} + \frac{1}{PRG_{res\text{-}soil\text{-}inh}} + \frac{1}{PRG_{res\text{-}soil\text{-}ext}} + \frac{1}{PRG_{res\text{-}soil\text{-}produce\text{-}ing\text{-}tot}}}$$

Figure C-6. 2017 Equation for Resident Soil PRG (continued)

For example, the 2017 online PRG calculator requires input for each individual element that makes up the overall particulate emission factor (PEF) in order to calculate site-specific PRG values. The calculator does not allow input of a single PEF value, which was the only PEF input parameter available in the 1994 calculations. Figure C-7 shows the PEF screen from the 2017 PRG calculator. Because some of the input data required to use the 2017 online PRG calculator were not in the 1994 dataset, the Excel calculator described in Section C2.3.3 was used. Although default values are available in the 2017 calculator, using default values from 2017 coupled with site-specific values from 1994 would result in a completely different scenario. For the purposes of this FYR risk evaluation, such a comparison would not be meaningful.

Default ▾ City (Climatic Zone) – Selection based on most likely climatic conditions for the site	11.32 U_t (equivalent threshold value)
.5 A_s (acres)	0.5 V (fraction of vegetative cover) unitless
4.69 U_m (mean annual wind speed) m/s	

Figure C-7. 2017 Input Required for Particulate Emission Factor (PEF)

C4.1.1 Radionuclide Constituent Evaluation Results

To be able to compare current and previous PRGs from OU3, the 2017 EPA online calculator was used as a basis to generate site-specific PRGs that could then be compared to the PRGs from 1994, assuming the same calculator data inputs for the residential exposure scenario. It should be noted that the 2017 calculations for the resident scenario do not take into account any vegetable consumption from the soil as these data were not included in the 1994 dataset.

Table C-15 presents the OU3 PRGs from 1994 and the Excel calculator 2017 at a risk level of 1×10^{-6} (1 in 1,000,000). As shown in the table, the PRGs are within the acceptable 1×10^{-6} risk range, except for U-234 and U-238. The PRG results for U-234 (45.3 pCi/g in 1994; 5.09 pCi/g in 2017) and U-238 (46.0 pCi/g in 1994; 5.63 pCi/g in 2017) changed significantly. An analysis of the changes to the PRGs for these two U isotopes indicate the overall risk from U-234 and U-238 have increased slightly due to slope factor changes. The comparison of slope factor changes from 1994 to 2017 is shown in Table C-8. Comparing the 1994 PRG concentrations for the resident scenario to the Excel calculator values demonstrates that the 1994 U-234 and U-238 PRGs would present a risk slightly below 1×10^{-5} (Table C-16), which is still within the EPA acceptable risk range. To provide perspective, the maximum concentration of U-234 and U-238 identified at OU3 in 1994 was in subsurface soil (DOE 1996). Uranium-234 was detected at 2.02 pCi/g, and uranium-238 was detected at 2.15 pCi/g, which are both below the 2017 resident PRGs calculated for this review. Based on this risk review, OU3 continues to meet the conditions for UU/UE.

Table C-15. PRGs for OU3 Residential Exposure Scenario (pCi/g at a 1×10^{-6} risk level)

Isotope	1994	2017 (using ICRP 107)
^{241}Am	2.37	3.14
^{239}Pu	3.43	3.30
^{234}U	45.3	5.09
^{235}U	0.17	0.54
^{238}U	46.0	5.63

Table C-16. Recalculated PRGs for U-234 and U-238 (pCi/g at a 9 × 10^{-6} risk level)

Isotope	1994	2017 (using ICRP 107)
^{234}U	45.3	45.8
^{238}U	46.0	50.7

C5.0 References

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Appendix D

RFLMA Contact Records

Appendix E

Groundwater and Surface Water Monitoring

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E1.0 Groundwater and Surface Water Monitoring

E1.1 Groundwater

The designated groundwater use classification at the COU is surface water protection. This is based on the fact that groundwater contaminated by historical operations emerges to surface water prior to exiting the COU. The numeric values for measuring potential effects of contaminated groundwater on surface water quality are the surface water standards in RFLMA Attachment 2, Table 1. It should be noted that the CAD/ROD and RFLMA incorporated some MCL values as surface water standards, in cases where surface water standards were not available.

The groundwater monitoring network includes four types of monitoring wells: AOC, Sentinel, Evaluation, and RCRA. The AOC wells provide data directly relevant to groundwater RAO 1; the Sentinel wells provide data directly relevant to groundwater RAO 2 and soil RAO 1 and are discussed in Section 6.1.2. The RCRA wells are directly related to the remedies implemented at the PLF and OLF and are discussed in Sections 6.1.4.1 and 6.1.4.2, respectively. The data collected during this FYR period at the Evaluation wells are summarized in this appendix.

The remedy in the CAD/ROD included the operation and maintenance of four groundwater collection and treatment systems (DOE, EPA, and CDPHE 2006). As a result of technology improvements and optimization during this FYR period, the number of treatment system was reduced to three, although there are still four groundwater collection systems. The reconfiguration of the treatment systems is summarized in Section 6.1.4.3 and discussed in detail in the COU annual reports. Monitoring of treatment system influent, effluent, and surface water locations associated with the treatment systems is summarized in this appendix.

E1.1.1 Evaluation Wells

Evaluation wells are typically located within plumes or near plume source areas or in the interior of the COU (Figure E-1). There are 42 Evaluation wells within the COU that are sampled every 2 years (biennially) in accordance with the RFLMA. The primary purpose of these wells is to determine when monitoring can be modified or discontinued. Data from these wells may also be used to support other objectives, such as providing input to groundwater modeling efforts, modification of groundwater monitoring and treatment requirements, or evaluation of changing contaminant conditions as indicated by downgradient AOC or Sentinel wells.

The RFLMA Attachment 2 decision logic flowchart Figure 9, "Evaluation Wells" (Appendix B), is relevant to Evaluation well data. In general, groundwater quality within plumes that were identified and characterized through the decades of pre-closure groundwater monitoring at the former RFP has changed little since site closure. As anticipated, due to their location within or adjacent to groundwater contaminant plumes, groundwater monitoring wells did not meet applicable RFLMA surface water standards at most Evaluation wells during this FYR period. Thus, continued monitoring of Evaluation wells is necessary to determine when groundwater is of sufficient quality to remove institutional control use restrictions and monitoring may cease. Discussion of plume-specific Evaluation well data may be found in the COU annual reports for 2012 and 2014 (DOE 2013; 2015) and 2016, when published.

During this FYR period, additional, nonroutine samples from Evaluation wells were collected following the heavy precipitation event in 2013 and the wet conditions in 2015. The COU annual reports for 2013 and 2015 provide an evaluation of these sample results (DOE 2014; 2016). Despite the relatively extreme weather events, groundwater quality in the COU in 2013 and 2015 was largely consistent with data reported in prior years.

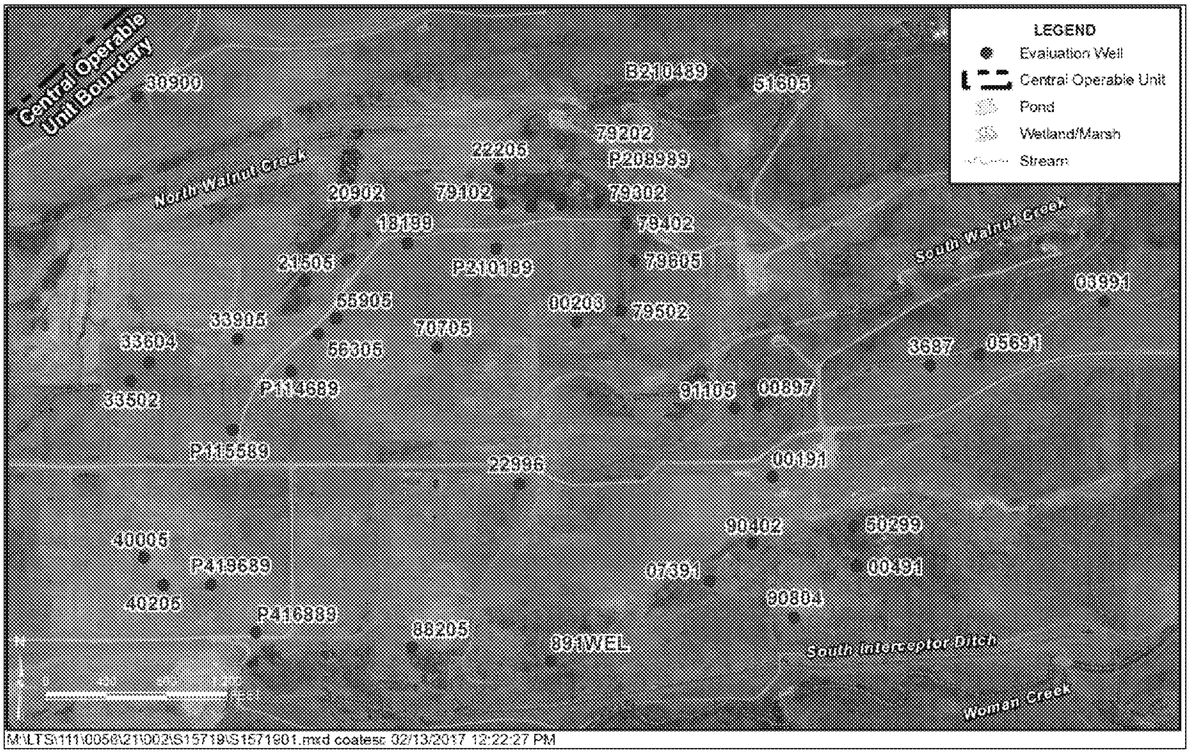

Figure E-1. Evaluation Well Locations

E1.1.2 Groundwater Treatment System Monitoring

The locations of the groundwater treatment systems in the COU are shown in Figure E-2. The groundwater treatment systems are designed to reduce target contaminant concentrations in groundwater and contaminant load to surface water. Each groundwater treatment system is monitored, at a minimum, for untreated influent and treated effluent and for impacts to surface water downstream of each subsurface effluent discharge point. Evaluation of groundwater treatment system performance determines whether (1) influent water quality indicates that treatment is still necessary, (2) effluent water quality indicates that system maintenance is required, and (3) surface water quality suggests impacts from inadequate treatment of influent. The RFLMA Attachment 2 decision logic flowchart Figure 11, "Groundwater Treatment Systems" (Appendix B), is relevant to the treatment systems monitoring data.

The groundwater treatment systems are being properly maintained and operated, but some constituents in system effluent have not consistently met applicable RFLMA standards. This triggers RFLMA consultation to determine if any mitigating actions should be implemented. The actions resulting from the RFLMA consultative process during this FYR period have focused on optimizing treatment capabilities of the systems and are summarized in Section 6.1.4.3.

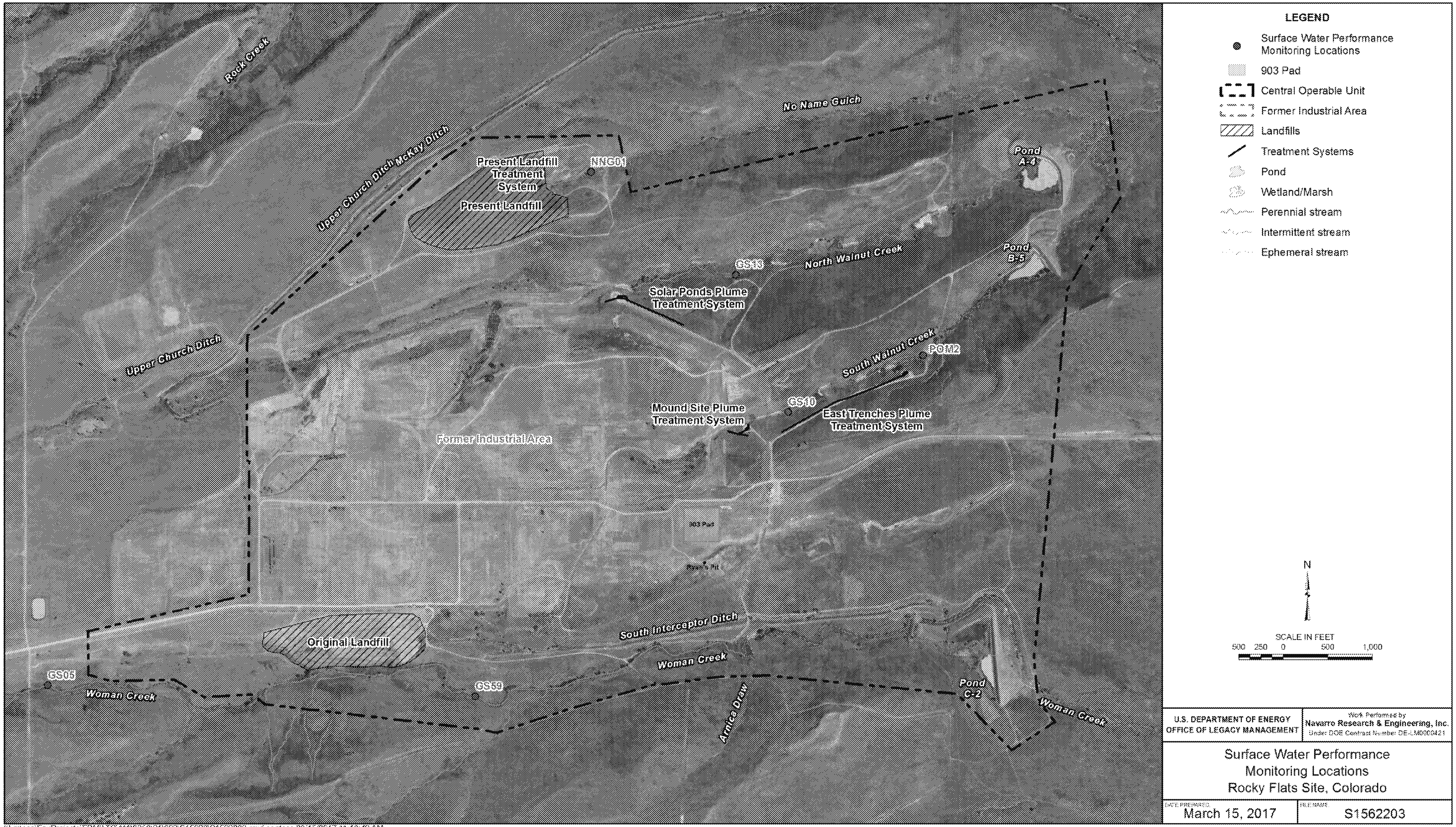

Figure E-2. Groundwater Treatment Systems and Surface Water Performance Monitoring Locations

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E1.1.2.1 PLFTS

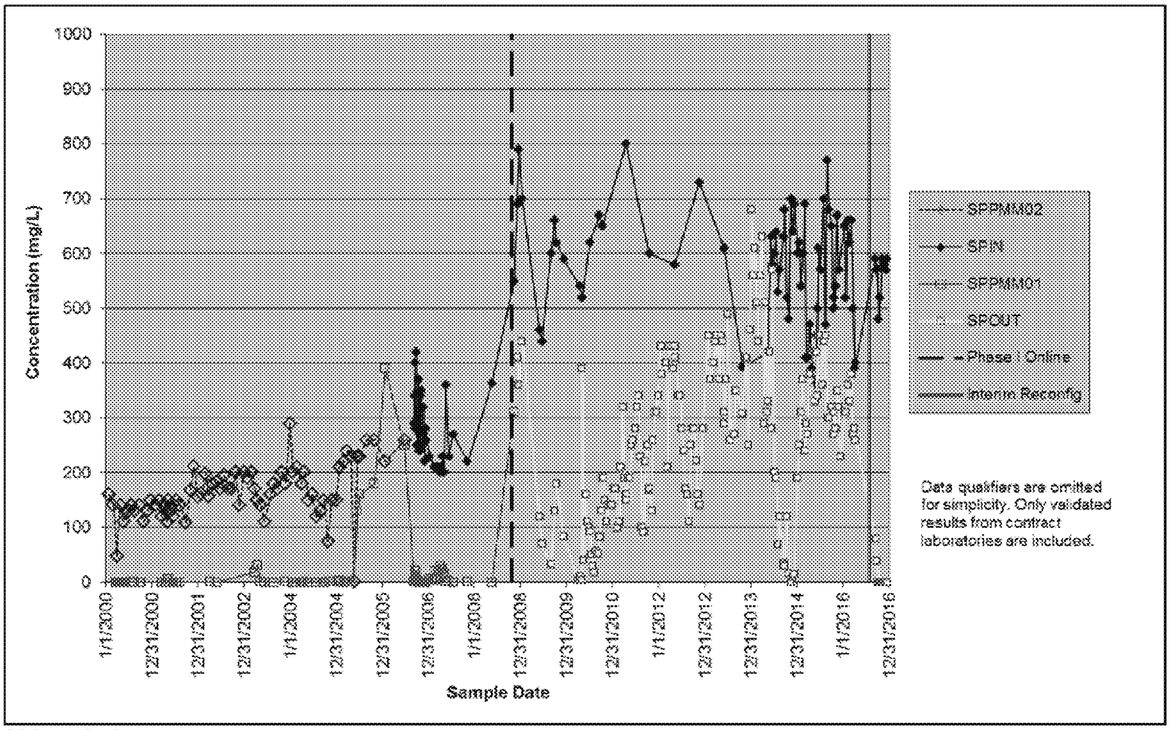
The PLFTS was installed in 2005 and consists of a gravity-fed, passive system designed to treat groundwater and seep water for VOCs. In contrast to the other treatment systems in the COU, there have been no alterations to this system since it was installed, and no opportunities for optimization have been identified. Operation and monitoring of the PLFTS during this FYR period is discussed in Section 6.1.4.1 and is not repeated herein. A yearly account of sampling data and evaluation of the PLFTS may be found in the COU annual reports.

E1.1.2.2 SPPTS

The SPPTS was installed in 1999 and was designed to treat groundwater contaminated with nitrate and uranium from the Solar Ponds source area. Throughout this FYR period, work has progressed in an attempt to refine treatment at the SPPTS and identify the most appropriate and efficient long-term system configuration. Optimization of this treatment system is summarized in Section 6.1.4.3. Evaluation and testing of system performance is ongoing and is planned to continue into the next FYR period. In conjunction with treatment system testing, additional nonroutine monitoring samples of the influent, effluent, and downstream surface water location GS13 have been collected.

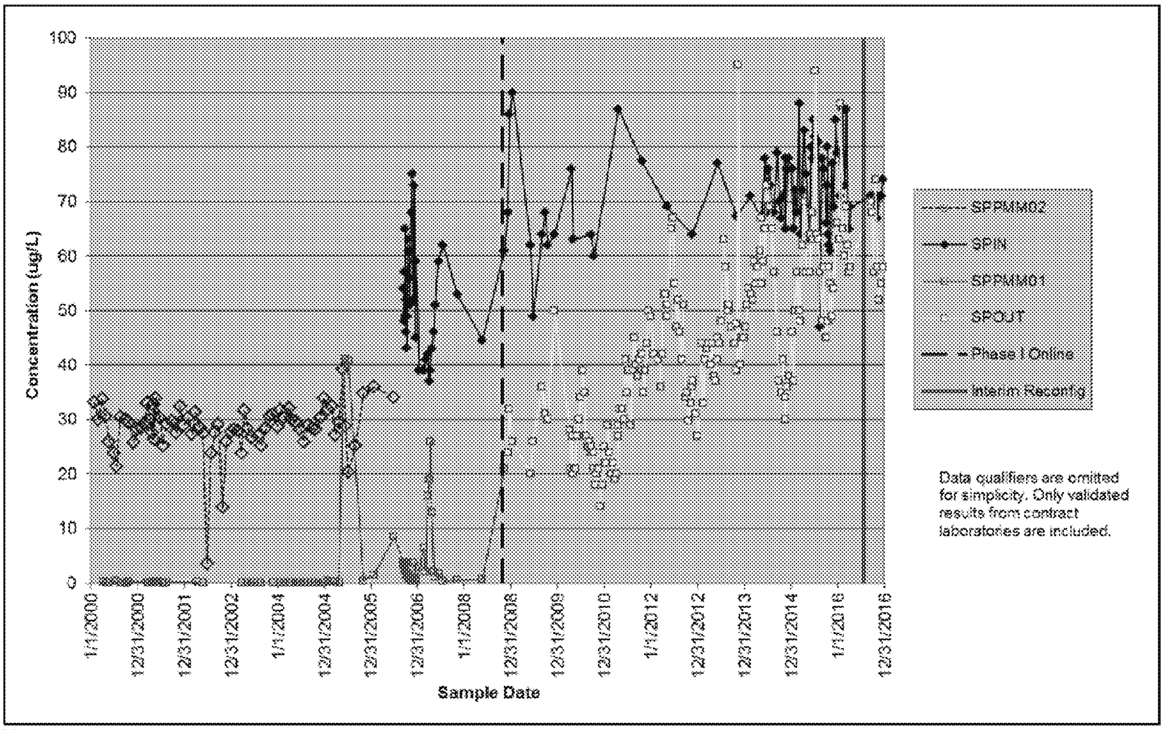
Figures E-3 and E-4 present nitrate and uranium data, respectively, for influent and effluent monitoring at the SPPTS from 2000 through 2016. While reduction of nitrate and uranium loads to surface water from the Solar Ponds plume has continued throughout this FYR period, the reduction of constituent concentrations to below applicable RFLMA surface water standards has not consistently been achieved. For both nitrate and uranium, routine samples of SPPTS influent and effluent have been above RFLMA standards during this FYR period, as have some samples from surface water monitoring location GS13. An evaluation of the Walnut Creek drainage system concluded that approximately 5% of the uranium load measured at location GS13 and approximately 20% of the nitrate load (prior to system reconfiguration) comes from SPPTS effluent (Wright Water Engineers 2015). This suggests that effluent from the SPPTS does not have a large impact on uranium concentrations detected in North Walnut Creek at GS13 or WALPOC. Although the nitrate standard at WALPOC has been continuously met in surface water samples, uranium concentrations have exceeded the RFLMA standard intermittently throughout this FYR period. The uranium 12-month rolling average at WALPOC exceeded the standard for a 4-month period in 2014–2015 and currently exceeds the standard as of December 2016. Uranium conditions at WALPOC are discussed further in Section 6.1.3.1. Based on the Walnut Creek evaluation, however, the concentrations of uranium at WALPOC do not appear to be a direct result of SPPTS operations.

In general, effluent conditions at the SPPTS did not show improvement during this FYR period until completion of the SPPTS interim reconfiguration project in late 2016, which focused on constructing a full-scale, test nitrate treatment component. Since reconfiguration completion, nitrate concentrations in SPPTS effluent have consistently been below RFLMA standards, with nitrate typically not detected in the effluent. The results of uranium treatment to date have proven less encouraging; however, efforts to identify an effective long-term system configuration continue through the RFLMA consultative process.



Abbreviations:
Interim Reconfig indicates when the 2016 interim reconfiguration project was completed.
Phase I Online = date when Phase I upgrades to collect additional impacted groundwater were completed.
SPPMM02 and SPIN = system influent
SPPMM01 and SPOUT = system effluent

Figure E-3. Total Nitrate Concentrations in SPPTS Influent and Effluent (2000–2016)



Notes:
SPPMM02 and SPIN = system influent
SPPMM01 and SPOUT = system effluent
Interim Reconfig = date when the 2016 interim reconfiguration was completed.
Phase I Online = date when Phase I upgrades to collect additional impacted groundwater were completed.

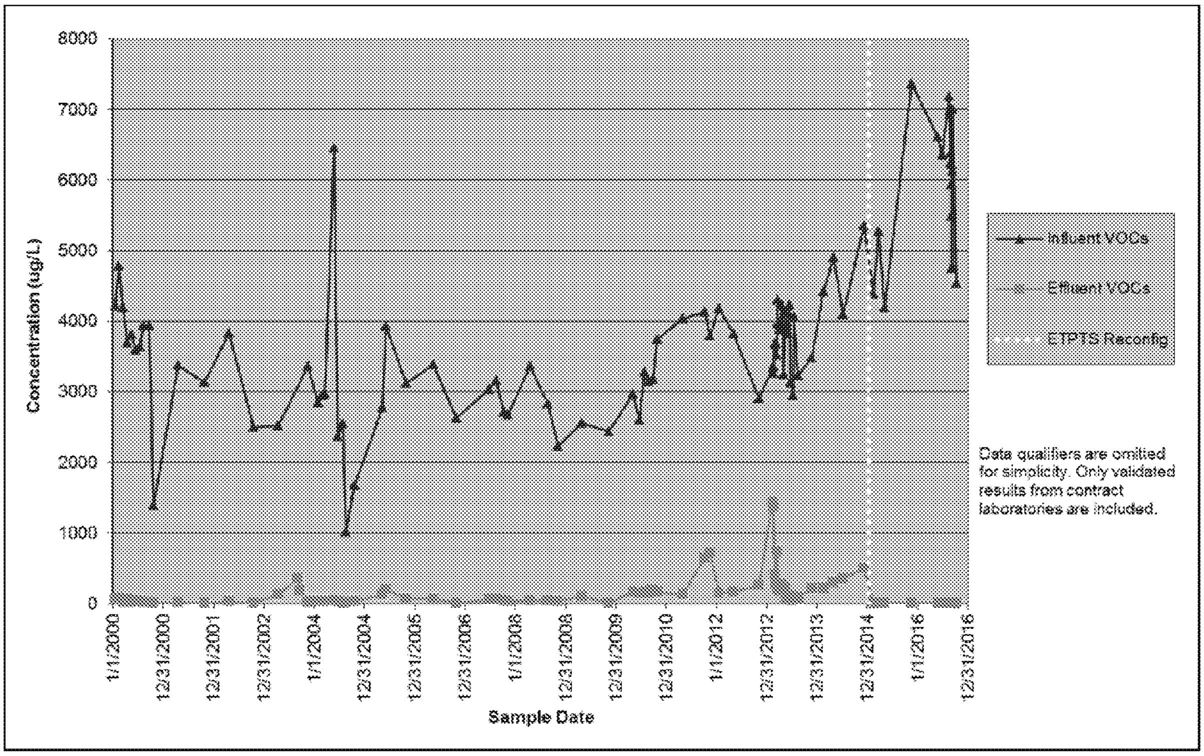
Figure E-4. Total Uranium in SPPTS Influent and Effluent (2000–2016)

E1.1.2.3 ETPTS

The ETPTS was designed to treat groundwater contaminated with VOCs from the East Trenches source area and was installed in 1999. Optimization of this treatment system is summarized in Section 6.1.4.3.

Figure E-5 presents total VOC concentration data for influent and effluent monitoring at the ETPTS from 2000 through 2016. Throughout this FYR period, several VOCs exceeded applicable RFLMA standards in both the influent and effluent. Since completion of the ETPTS reconfiguration in early 2015, however, treatment effectiveness is much improved and effluent concentrations of VOCs are almost always below applicable RFLMA standards. Of the 12 effluent samples collected since the reconfiguration project was completed, concentrations of TCE exceeded the RFLMA standard in three samples (the highest concentration of TCE in ETPTS treated effluent since the reconfiguration was 3.3 µg/L; the standard is 2.5 µg/L). Figure E-5 illustrates that the ETPTS has been effective, now much more effective, in reducing contaminant concentrations in groundwater treated by the system and reducing contaminant load to surface water. The reconfiguration of the system to include an air stripper has significantly reduced contaminant concentrations in ETPTS effluent.

The surface water performance monitoring location associated with the ETPTS is POM2 (Figure E-2). Low concentrations of VOCs were occasionally detected in surface water samples from this location collected during this FYR period. However, no VOCs have ever exceeded their respective RFLMA standards at this location.



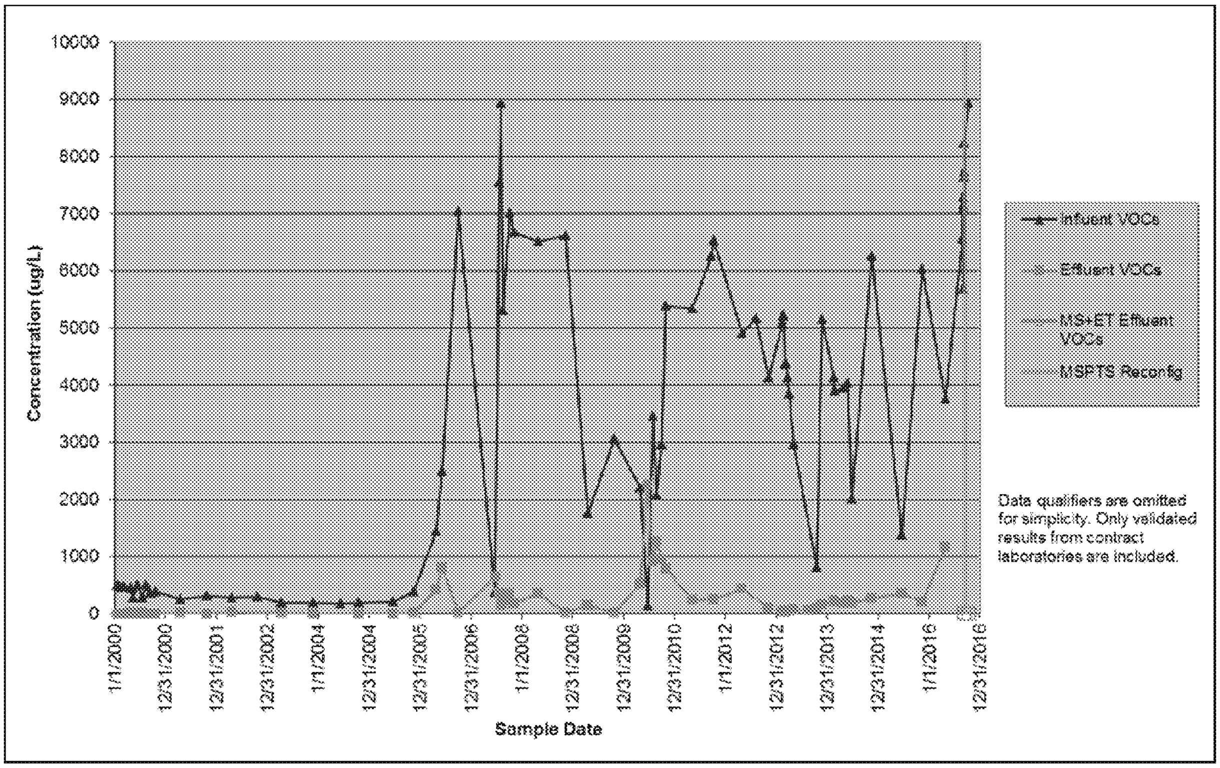
Notes:
"ETPTS Reconfig" refers to when the ETPTS Reconfiguration Project to install a commercial air stripper was completed.
Data in late 2016 represent treatment of combined MSPTS+ETPTS influent.

Figure E-5. Total Detected VOCs in ETPTS Influent and Effluent

E1.1.2.4 MSPTS

The MSPTS was designed to treat groundwater contaminated with VOCs from the Mound source area and was installed in 1998. Groundwater impacted by residual contaminants in the nearby Oil Burn Pit No. 2 (OBP No. 2) area was directed to this treatment system beginning in 2005. Optimization of this treatment system is summarized in Section 6.1.4.3.

Figure E-6 presents total VOC concentration data for influent and effluent monitoring at the MSPTS from 2000 through 2016. Throughout this FYR period, several VOCs have exceeded applicable RFLMA standards in both the influent and effluent. In late 2016, reconfiguration of the MSPTS was completed, and groundwater from the Mound plume was routed to the ETPTS for treatment (CR 2015-04). The reconfiguration resulted in significant improvement in treatment of VOCs originating at the Mound and OBP No. 2 areas. The treatment of TCE has posed the greatest challenge to the MSPTS since operations began. Following system reconfiguration, however, TCE in system effluent has consistently been below the RFLMA standard. Figure E-6 illustrates that throughout the operating life of the MSPTS, the system was effective in reducing contaminant concentrations in groundwater treated by the system and in reducing contaminant load to surface water. The last data points shown in Figure E-6 for MSPTS effluent represent the treatment of combined MSPTS and ETPTS influent and show that all applicable RFLMA standards were met.



Notes:
VOC data shown represent arithmetic sums of all validated detections at locations MOUND R1-0 (influent) and MOUND R2-E (effluent) until the latter location was eliminated in late 2016.
"MSPTS Reconfig" refers to the date when the MSPTS Reconfiguration Project was completed, routing MSPTS influent to the ETPTS for treatment.
Data in late 2016 represent treatment of combined MSPTS+ETPTS influent.

Figure E-6. Total VOCs in MSPTS Influent and Effluent, 2000 Through 2016

For the majority of this FYR period, the surface water performance monitoring location associated with the MSPTS was GS10, located in the South Walnut Creek drainage (Figure E-2). No VOCs were detected above applicable RFLMA standards at GS10 in 2012 or 2013; TCE was detected above the RFLMA standard at this location in 2014, 2015, and 2016. The high groundwater flows resulting from heavy precipitation in 2013 and 2015, and the consequentially reduced residence time for influent within the ZVI reactive media in the MPSTS, are factors in these TCE exceedances. Since treatment of Mound and OBP No. 2 plume groundwater no longer occurs at the MSPTS, surface water location GS10 is no longer used to evaluate treatment system performance. This role is now filled by POM2, the surface water performance location assigned to the ETPTS, as discussed below. The GS10 location, however, continues to serve as a POE in the surface water monitoring network in the COU.

E1.2 Surface Water

The protection of surface water was a basis for making cleanup decisions at the former RFP so that surface water within, and leaving, the COU would be of sufficient quality to support all uses.

The applicable surface water uses are consistent with the following Colorado surface water use classifications:

- Water Supply
- Aquatic Life—Warm 2
- Agriculture
- Recreation N (North Walnut Creek, South Walnut Creek, Pond C-2)
- Recreation E (Woman Creek)

These classifications are applicable to surface water in the COU; however, the institutional controls established in the remedy for the COU prohibit some of these uses, specifically, water supply and agriculture uses. That is, although the state regulations mandate the protection of the surface water in the COU to support each of the use classifications above and surface water must meet the water quality standards for each classification, the ICs prohibit some uses.

The surface water monitoring network includes three types of locations: points of compliance (POCs), points of evaluation (POEs), and performance monitoring locations. Evaluation of data collected at the POCs during this FYR period are directly relevant to surface water RAO 1 and are discussed in Section 6.1.3. This section summarizes data collected during this FYR period at the POEs and performance monitoring locations.

E1.2.1 Points of Evaluation

The POEs (locations GS10, SW027, and SW093) are located upstream of the POCs (Figure 2) and provide an early indication of the quality of surface water flowing toward the POCs. The RFLMA Attachment 2 decision logic flowchart Figure 6, "Points of Evaluation" (Appendix B), is relevant to data collected at these locations. During this FYR period, there were periodic exceedances of the surface water quality standards for actinides (e.g., plutonium and americium) and uranium at locations GS10 and SW027. The exceedances of 12-month rolling averages for uranium, americium, and plutonium at GS10 and americium and plutonium at location SW027 resulted in reportable conditions for these locations. There were no reportable conditions during this review period for location SW093.

E1.2.1.1 GS10

Surface water monitoring location GS10 is the POE in South Walnut Creek upstream of WALPOC. This location monitors surface water from the drainage area for a major portion of the former industrial area of the RFP. The monitoring equipment at GS10 was upgraded and relocated in 2013 to avoid the potential for monitoring interruptions due to the movement of an adjacent hillside slump. The new location is approximately 40 feet east of its original location (CR 2013-01).

Uranium. The 12-month rolling average for uranium at GS10 (18.8 µg/L) exceeded the RFLMA standard of 16.8 µg/L at the end of April 2011 (CR 2011-04). The plan to evaluate this reportable condition included the collection of surface water and groundwater samples from locations upstream and downstream of GS10. Based on these results, additional evaluation of this condition was determined necessary (CR 2011-05). The 12-month rolling average for uranium at

GS10 did not fall below the RFLMA standard until March 2013. The average remained below the standard until the end of May, when the standard was again exceeded. In September 2013, the 12-month rolling average for uranium (14.6 µg/L) fell below the RFLMA standard and remained below the standard through the end of this FYR period. Figure E-7 presents the 12-month rolling average data for total U at GS10 from 2005–2016.

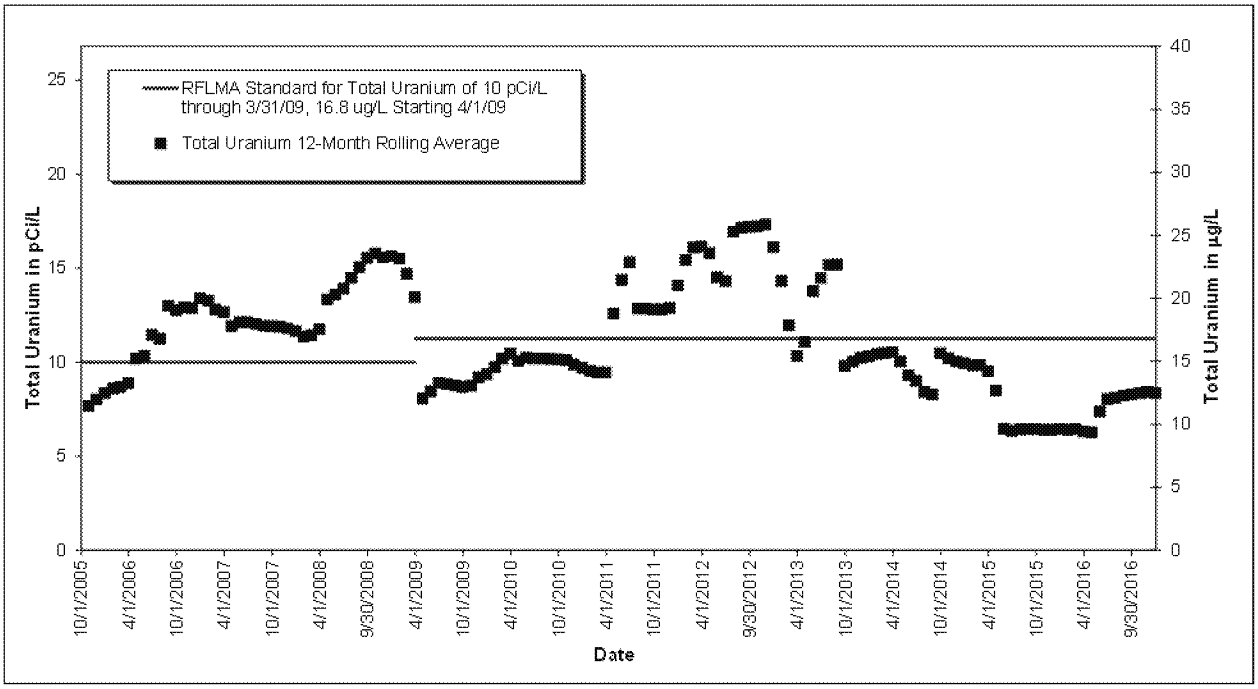


Figure E-7. Volume-Weighted 12-Month Rolling Average Total Uranium Concentrations at GS10: Post-Closure Period

From the initial reportable condition at GS10 in April 2011 until late 2013, uranium concentrations downstream of GS10 at WALPOC were below the RFLMA standard. In December 2013, the 30-day average uranium concentration (16.9 µg/L) at WALPOC exceeded the standard (16.8 µg/L) and became a reportable condition (CR 2014-05). Other reportable conditions for uranium occurred at WALPOC in October 2014 (CR 2015-01), January 2016 (CR 2016-01), and December 2016 (CR 2017-02). The 12-month rolling averages for uranium WALPOC from 2011 through the end of 2016 are shown in Figure 5. Data collected prior to mid-2015 to evaluate these reportable conditions were included in extensive evaluation of conditions in the Walnut Creek drainage system. The results of this evaluation and additional discussion of the reportable conditions at WALPOC are presented in Section 6.1.3.1.

Americium and Plutonium. In August 2011, the 12-month rolling average for americium at location GS10 (0.21 pCi/L) exceeded the RFLMA standard of 0.15 pCi/L, resulting in a reportable condition at GS10 (CR 2011-08). The plan to evaluate this reportable condition included the inspection of upstream areas for seeps and indications of soil erosion, the collection of surface water and seep samples from upstream and downstream locations, and the review of historical data. At the time, the Pu concentration at GS10 was not reportable, but since Pu and Am are found together and behave similarly in the environment, the evaluation plan for the Am reportable condition included sample analyses for both Am and Pu. In May 2012, the 12-month rolling average for Pu at location GS10 (0.17 pCi/L) exceeded the RFLMA standard of 0.15 pCi/L and became a reportable condition. Figure E-8 presents the 12-month rolling averages for Am and Pu from 2005 through 2016.

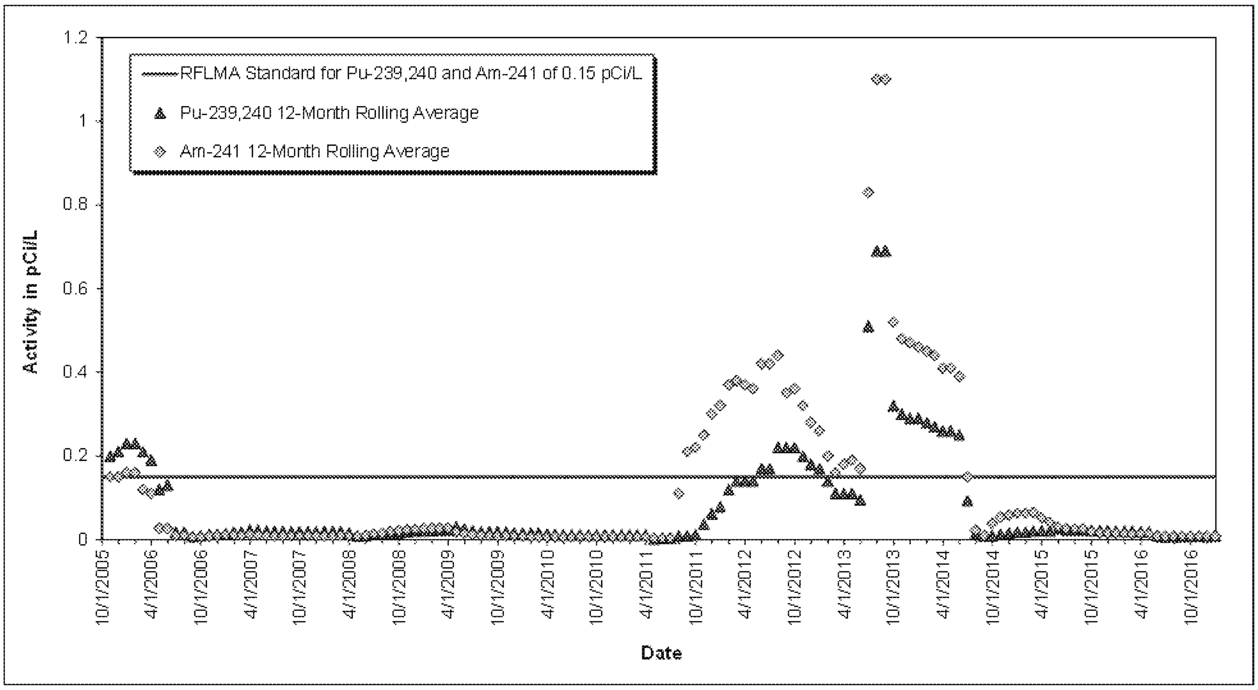


Figure E-8. Volume-Weighted 12-Month Rolling Average Plutonium and Americium Activities at Location GS10: Post-Closure Period

The evaluation of the Am and Pu reportable conditions focused on assessment of the potential transport mechanisms for these radionuclides, namely, soil erosion and transport in water via various mechanisms. Inspection of the location GS10 drainage did not identify any obvious soil erosion that could potentially impact surface water quality. This observation, coupled with the fact that the elevated Pu/Am results for GS10 were obtained during relatively dry conditions at the site, suggested that soil/sediment transport was not a primary contributor to the reportable condition at GS10. Sampling of several seeps identified upstream of GS10 (DOE 2014) suggested that seeps may be contributing some Pu/Am to surface water at location GS10; however, seep contributions alone could not adequately explain the measured Pu/Am concentrations at GS10. Evaluation of data for colloidal transport did not provide additional insight into the reportable condition evaluation at GS10.

Mitigating actions were not required to address these reportable conditions because downstream conditions remained well below the RFLMA standards for Pu and Am during the evaluation period. The downstream locations associated with GS10 at the time are shown in Figure E-9; monitoring data for these locations are shown in Figures E-10 and E-11. Pu and Am 12-month averages at GS10 have remained below the RFLMA standards from mid-2014 through the end of this FYR period.

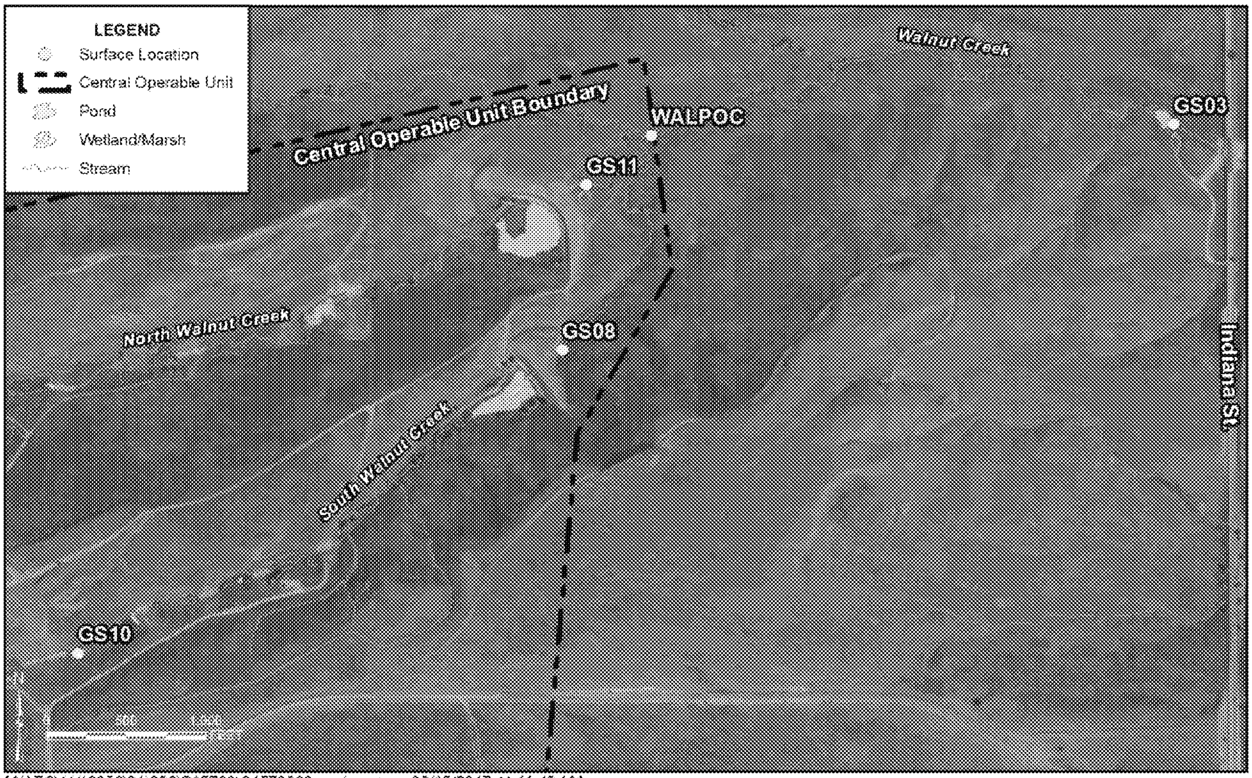
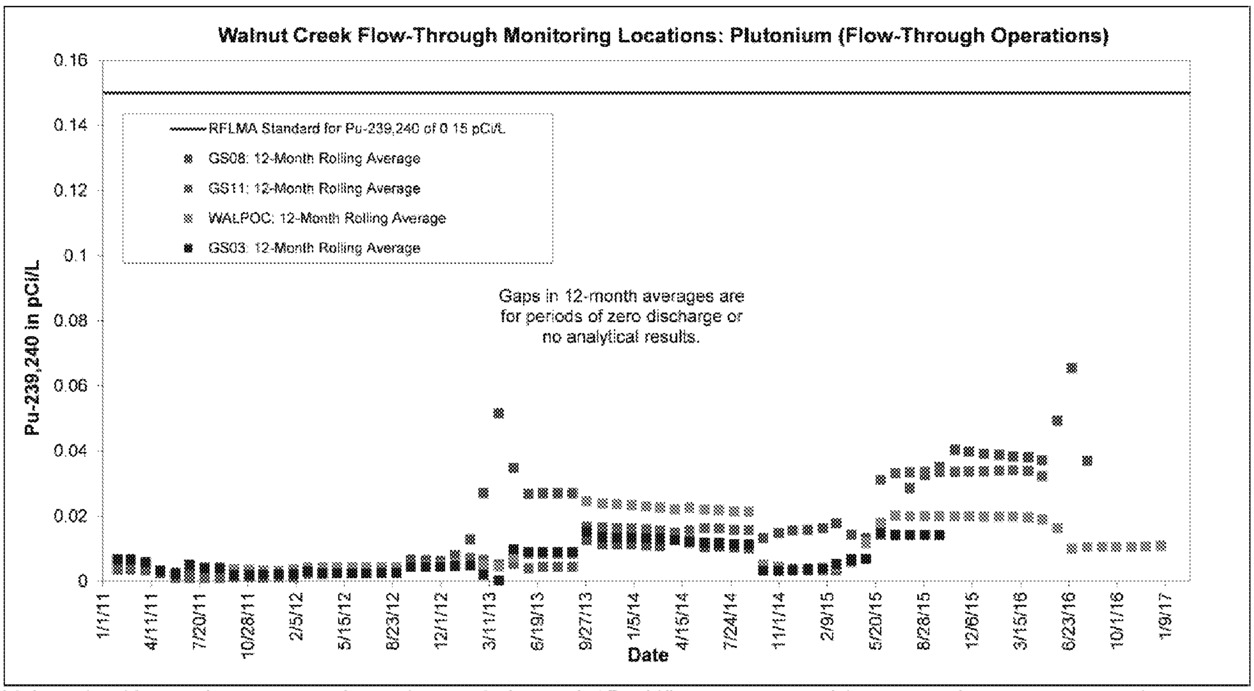
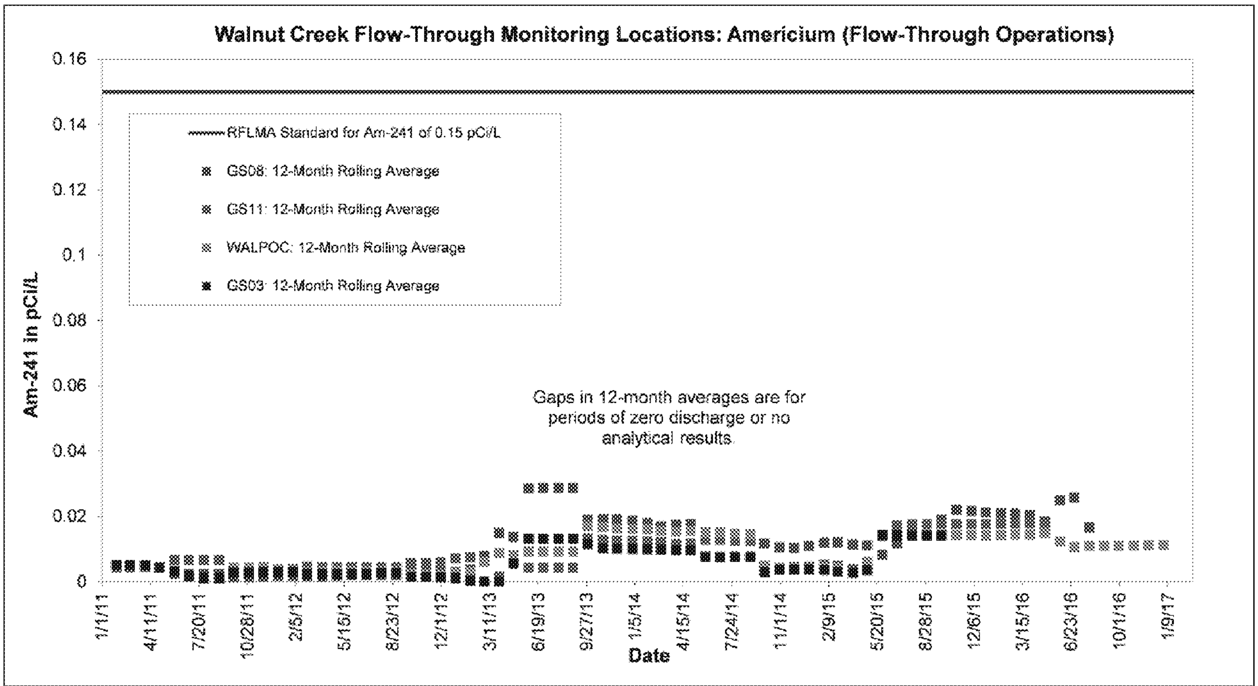


Figure E-9. GS10 and Associated Monitoring Locations



Values for 12-month averages shown here relative to 0.15 pCi/L are presented for comparison purposes only.

Figure E-10. Average Plutonium Activities at Locations Downstream of Location GS10



Values for 12-month averages shown here relative to 0.15 pCi/L are presented for comparison purposes only.

Figure E-11. Average Americium Activities at Locations Downstream of Location GS10

E1.2.1.2 SW027

Surface water monitoring location SW027 is the POE at the eastern (downstream) end of the South Interceptor Ditch (SID), upstream of WOMPOC (Figure E-12). Figure E-13 presents the 12-month rolling average Pu and Am data for SW027 from site closure in 2005 through 2016.

The 12-month rolling average for plutonium at SW027 (0.16 pCi/L) initially exceeded the RFLMA surface water standard of 0.15 pCi/L in April 2010 (CR 2010-06). Following consultation, mitigating actions were completed in December 2010, which included reseeding and installation of additional erosion controls in the SID drainage area (DOE 2010). These efforts were an attempt to reduce the movement of residual Pu in soil from the 903 Pad/Lip Area and into the SID. The 2006 RI/FS acknowledged that remaining concentrations of Pu in soil from this area, while below the soil cleanup action level, could result in the exceedance of surface water quality standards should Pu be transported through soil erosion (DOE 2010). Inspection of the area and evaluation of upstream and downstream data did not identify any new plutonium source. The concentration of plutonium during this time frame at WOMPOC, downstream of SW027, did not exceed the RFLMA standard. Additional detail regarding evaluation of Pu at SW027 is found in the 2011 annual report (DOE 2012). No samples were collected at SW027 from October 2010 until February 2013, due to lack of surface water flow. All SW027 samples collected in 2013 were below the RFLMA standards for Am and Pu (Figure E-13); no composite samples were collected in 2014 due to lack of flow. Location SW027 was dry until March 2015, when sampling resumed.

A reportable condition for plutonium with a 12-month rolling average of 0.22 pCi/L was documented shortly after sampling resumed in April 2015 (CR 2015-05). The 12-month rolling average for Am subsequently exceeded the standard in June 2015. Following consultation, additional measures were implemented to enhance the vegetation and erosion controls implemented in 2010 and 2011. These measures were mostly completed by August 2015 and included the addition of straw wattles, GeoRidge berms, and woodstraw in the SID drainage area; additional erosion matting and GeoRidge berms in the SID was completed in March 2016. The 12-month rolling averages for Pu at SW027 continued to exceed the RFLMA standard through the end of this FYR period. Americium concentrations continued to exceed the RFLMA standard until June 2016; since June 2016 and through the end of this FYR period Am has been below the standard.

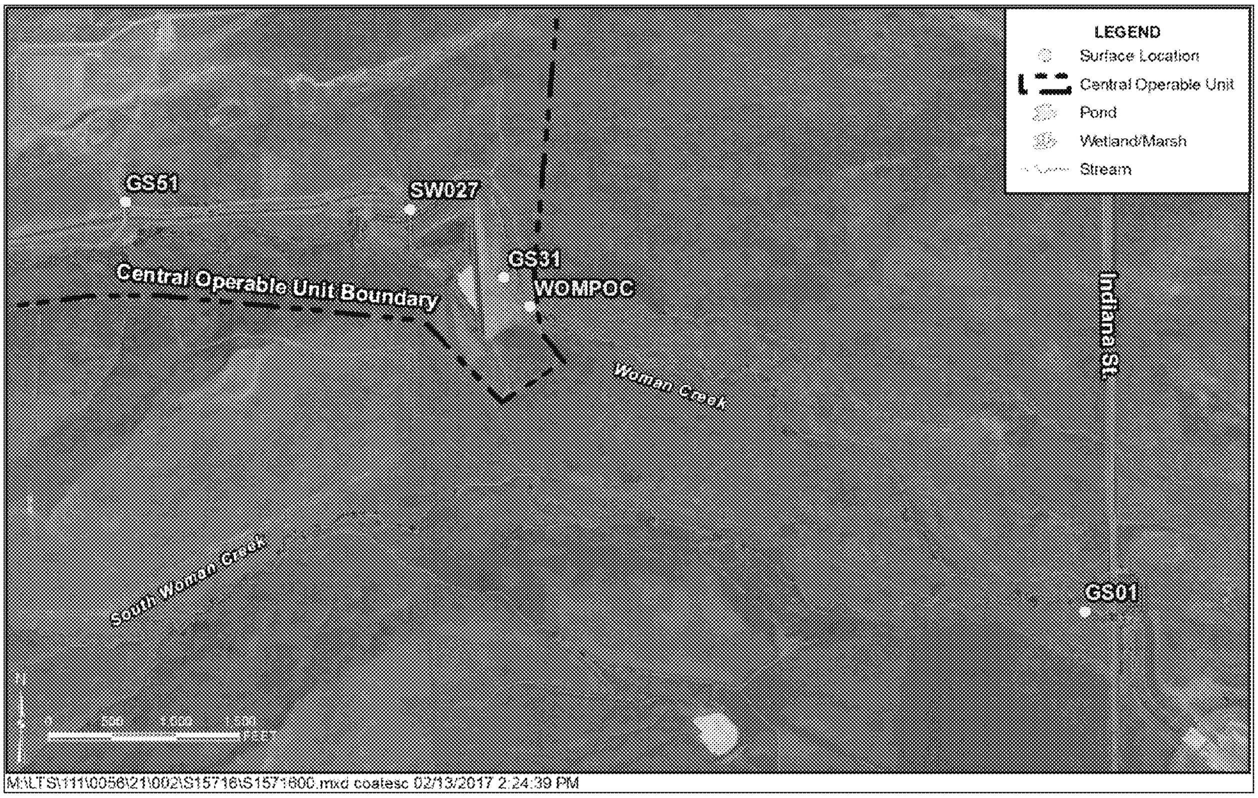


Figure E-12. SW027 and Associated Monitoring Locations

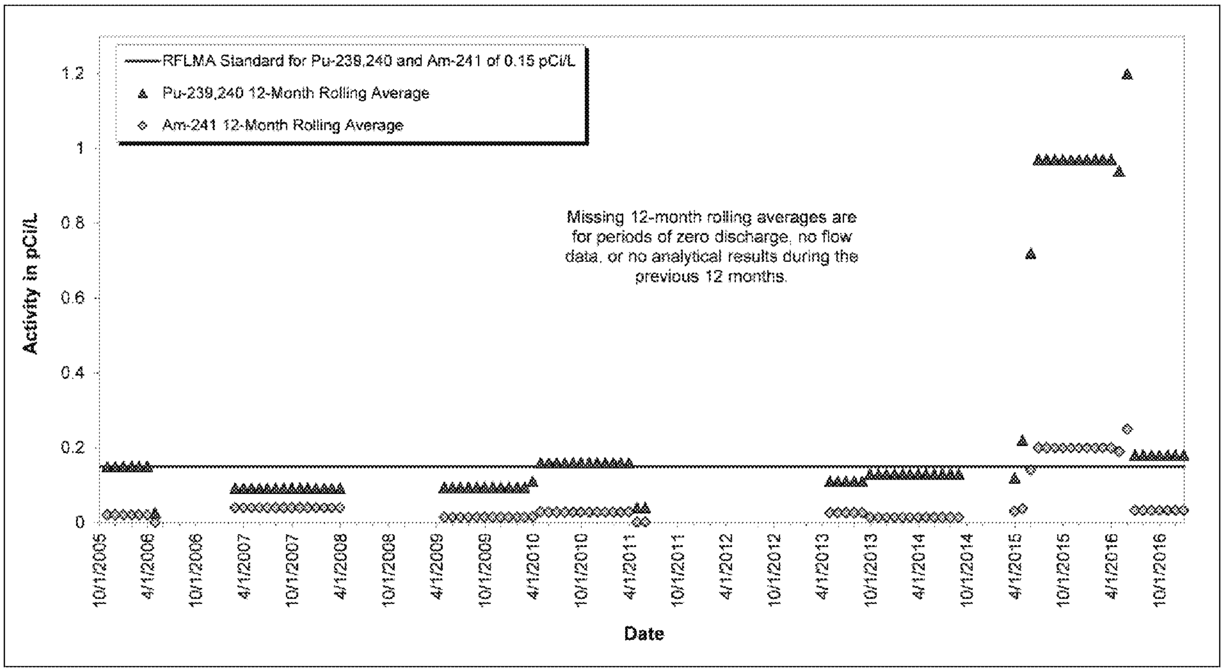


Figure E-13. Volume-Weighted 12-Month Rolling Average Plutonium and Americium Activities at Location SW027: Post-Closure Period Ending CY 2016

E1.2.2 Performance Monitoring Locations

Performance monitoring locations are downstream of specific remedies (Figure E-2) and are used to determine the short- and long-term effectiveness of these remedies where known contaminants may affect surface water. The results of monitoring at these locations are discussed in the sections indicated below. The performance monitoring locations are as follows:

- NNG01, which monitors surface water downstream of the PLF and PLFTS (see Section 6.1.4.1)
- GS13, which monitors surface water downstream of the SPPTS (see Section E1.1.2.2)
- GS10, which monitors surface water downstream of the MSPTS (see Section E1.2.1.1)
- POM2, which monitors surface water downstream of the ETPTS (see Section E1.1.2.3)
- GS05, which monitors surface water upstream of the OLF (see Section 6.1.4.2)
- GS59, which monitors surface water downstream of the OLF (see Section 6.1.4.2)

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DOE (U.S. Department of Energy), 2016. *Rocky Flats Site Annual Report of Site Surveillance and Maintenance Activities, Calendar Year 2015*, LMS/RFS/S13696, Office of Legacy Management, April.

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Wright Water Engineers, Inc., 2015. *Evaluation of Water Quality Variability for Uranium and Other Selected Parameters in Walnut Creek at the Rocky Flats Site*, Rev. 1, September.

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Appendix F

Documents Reviewed

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The following documents were reviewed as part of the FYR process to form the basis of the technical assessment of remedy protectiveness in the Central Operable Unit.

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Annual Report of Site Surveillance and Maintenance Activities at the Rocky Flats, Colorado, Site, Calendar Year 2014, LMS/RFS/S12421, U.S. Department of Energy Office of Legacy Management, April 2015.

Annual Report of Site Surveillance and Maintenance Activities at the Rocky Flats Site, Colorado, Calendar Year 2015, LMS/RFS/S13696, U.S. Department of Energy Office of Legacy Management, April 2016.

Annual Report of Site Surveillance and Maintenance Activities at the Rocky Flats Site, Colorado, Calendar Year 2016, LMS/RFS/S15402, U.S. Department of Energy Office of Legacy Management, due to be posted April 2017.

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Original Landfill Monitoring and Maintenance Plan, LMS/RFS/S05516, U.S. Department of Energy Office of Legacy Management, September 2009.

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Rocky Flats Site, Colorado, Site Quarterly Report of Site Surveillance and Maintenance Activities, Third Quarter Calendar Year 2012, LMS/RFS/S09514, U.S. Department of Energy Office of Legacy Management, January 2013.

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Rocky Flats, Colorado, Site Quarterly Report of Site Surveillance and Maintenance Activities, Second Quarter Calendar Year 2013, LMS/RFS/S10694, U.S. Department of Energy Office of Legacy Management, October 2013.

Rocky Flats, Colorado, Site Quarterly Report of Site Surveillance and Maintenance Activities, Third Quarter Calendar Year 2013, LMS/RFS/S11334, U.S. Department of Energy Office of Legacy Management, January 2014.

Rocky Flats, Colorado, Site Quarterly Report of Site Surveillance and Maintenance Activities, First Quarter Calendar Year 2014, LMS/RFS/S11979, U.S. Department of Energy Office of Legacy Management, July 2014.

Rocky Flats, Colorado, Site Quarterly Report of Site Surveillance and Maintenance Activities, Second Quarter Calendar Year 2014, LMS/RFS/S12195, U.S. Department of Energy Office of Legacy Management, October 2014.

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Appendix G

Site Inspection Checklist

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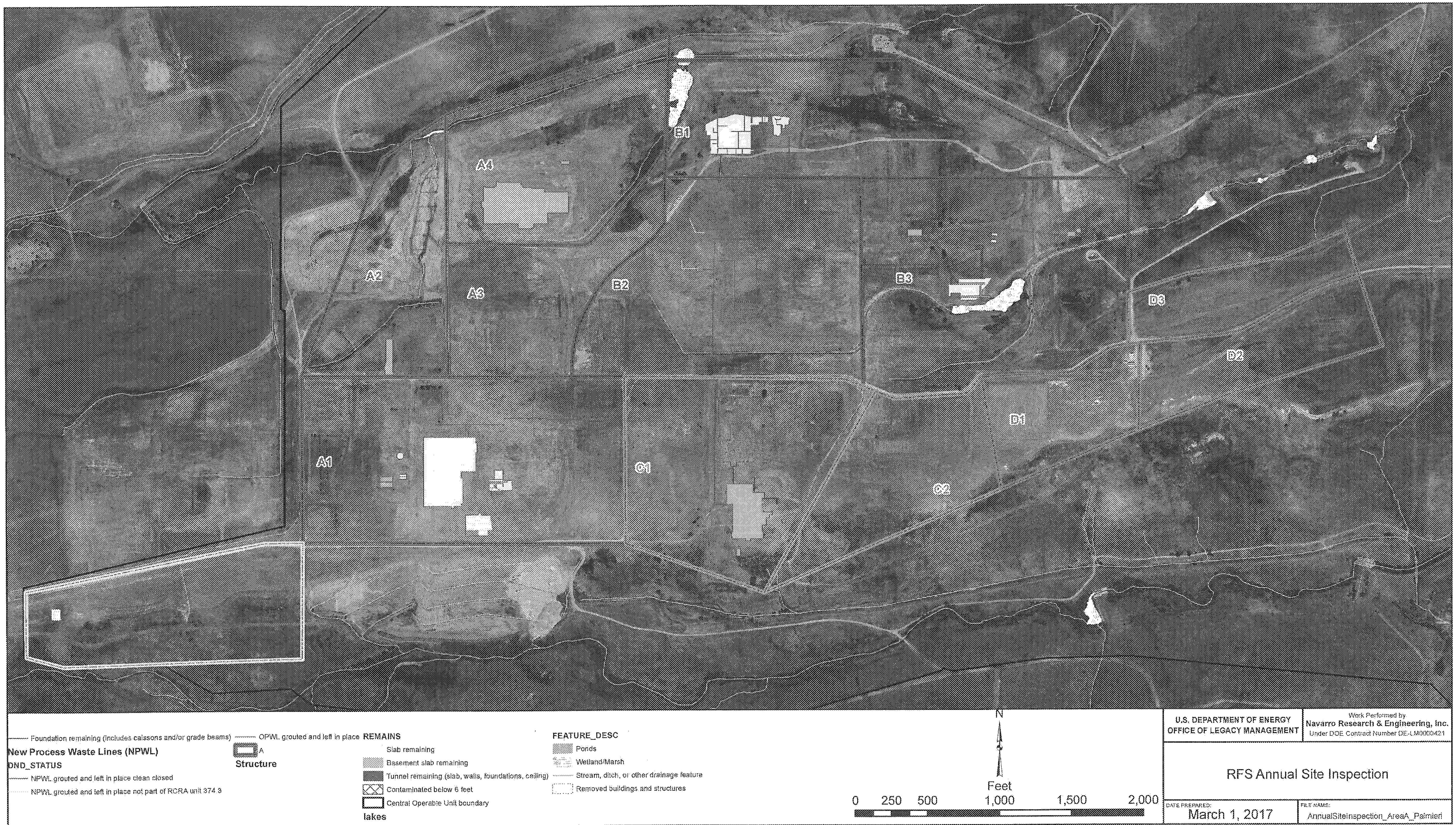

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Annual Site Inspection Check List (see RFLMA Attachment 2, Sections 5.3.4, 5.3.6, and 5.4.3)

Date 3/16/17 Inspection Area: A

Inspection performed by (print each name): CHUCK BROWN, LINDA KAISER, DANA SANTI, SCOTT SURDKHAK

Check all boxes that apply, put ID# on flag and place flag marker in location of observation for follow up.

Flag ID#	Evidence of Soil Erosion or Deposition	Evidence of Cracks, Rills, Gullies	Evidence of Sink Holes or Burrows	Evidence of Depressions or Subsidence	Evidence of Institutional Control Violation[1]	Problem with signs or other physical controls[2]	Adverse biological condition	Photo(s) taken?[3]
A2-1								Y
A3-1				✓				Y
A4-1				✓				Y
A4-2								Y

Notes (Reference Flag ID#):

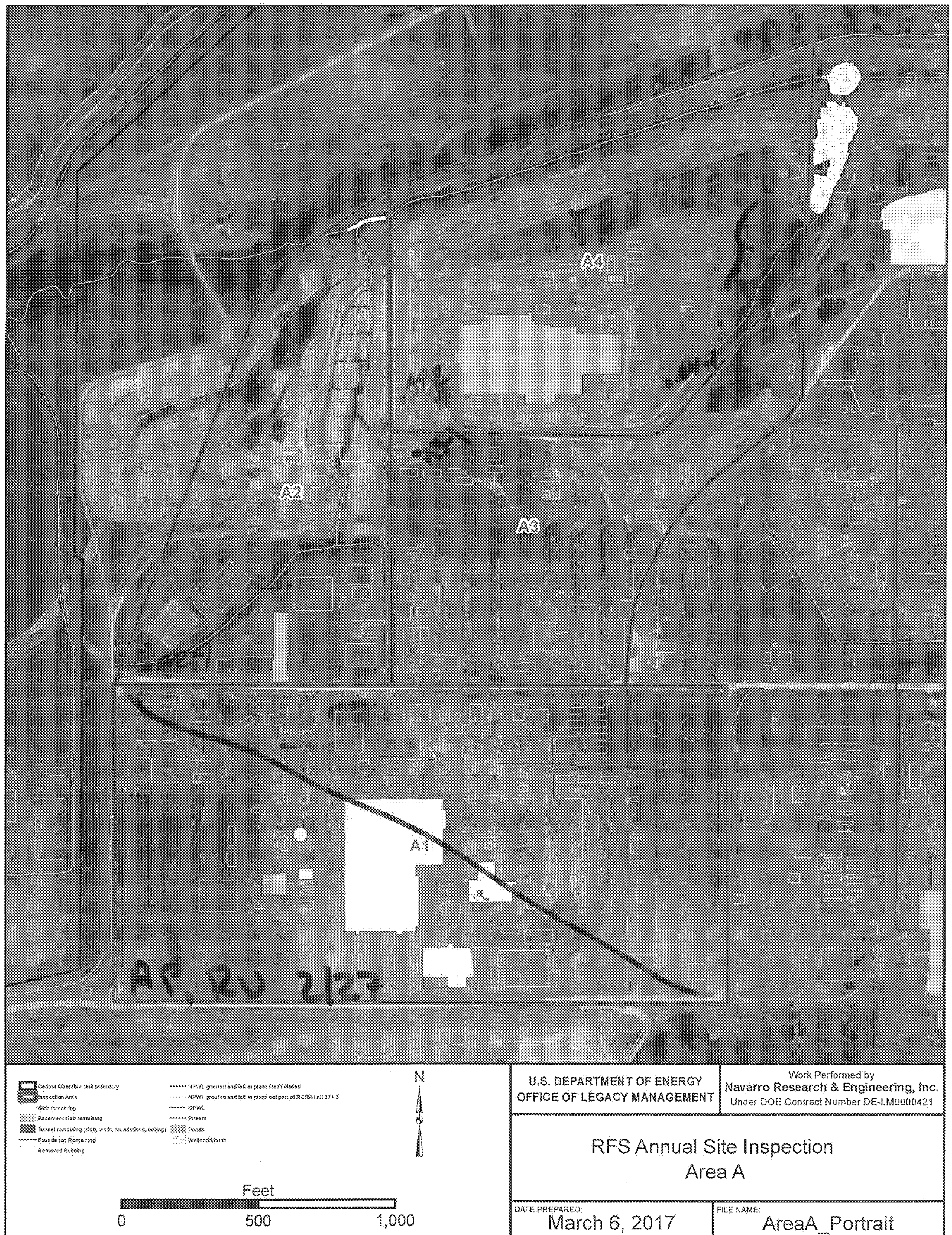
A2-1 - BURIED METAL NEAR FUNCTIONAL CHANNEL

A3-1 - DEPRESSION SW OF BLDG 371 2FT DIA BY 6-8 INCHES DEEP

A4-1 - DEPRESSION SE OF BLDG 371/374 2FT-4FT DIA BY APPROX. 1FT DEEP.

A4-2 - STEEL PIPE AND CONDUIT IN GROUND WEST OF 371

[1] Indicate the RFLMA IC# (RFLMA Attachment 2, Table 1–7) for which violation is indicated.
[2] These are required to be inspected quarterly per RFLMA Attachment 2 Section 5.3.5, and completion is documented separately—documented here if problem noted during Annual Inspection.
[3] If photo taken, show location and orientation of photo on Area map.


A4
A2
A3
A1
AP, RV 2/27
Central Operable Unit boundary
Inspection Area
Slab remaining
Basement slab remaining
Tunnel remaining (slab, walls, foundations, ceiling)
Foundation Remaining
Removed Building
NPWL grouted and left in place clean closed
NPWL grouted and left in place not part of RCRA unit 37.3
OPWL
Stream
Ponds
Wetland/Marsh
N
Feet
0
500
1,000
U.S. DEPARTMENT OF ENERGY
OFFICE OF LEGACY MANAGEMENT
Work Performed by
Navarro Research & Engineering, Inc.
Under DOE Contract Number DE-LM0000421
RFS Annual Site Inspection
Area A
DATE PREPARED:
March 6, 2017
FILE NAME:
AreaA_Portrait
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Area B 2017 Annual Site Inspection

Location	Item	Comment	Northing	Easting
B1	Trash	b-1 trash	750259.82822100000	2083336.83082000000
B2	Rebar	b-2 rebar	749880.47957100000	2083470.18718000000
B2a	Trash ~20 ft east of B2	east of b-2 trash 20 ft	749888.85192900000	2083495.58936000000
B3	Possible subsidence S end of Solar Ponds area	b-3 possible subsidence s end of	750407.21769000000	2084994.10867000000
B4	Wire sticking out of ground	b-4 wire	750309.79629700000	2085719.08163000000
B5	Conduit	b-5 conduit	750029.79423300000	2085895.06652000000
B5	Gray plastic pipe	b-5a gray plastic pipe	749998.94816600000	2085836.33173000000
B6	Plastic sheeting buried in ground by trees	b-6 plastic sheeting	750173.92911500000	2085242.35227000000
B7	Wire sticking out of ground		750222.58715400000	2084595.37194000000
B8	Multiple rebars sticking out of grd		749477.87670100000	2084590.00253000000
B9	Grounding rod sticking out of grd	b-9 grd rod	751122.23102400000	2085599.24854000000
B10	Conduit sticking out of grd	b-10 conduit	751213.89061800000	2084989.57128000000
B11	771 area - depression/subsidence	slight depression 771 b-12	751138.61517800000	2084078.94581000000
B12	Rebar sticking out of grd in trees		750675.51931900000	2083420.63610000000
B13	771 area - N/S linear subsidence	b-13 771 n-s depression	750977.54693000000	2083907.00783000000
B14	771 area - circular depression	b-14 depression	750907.68552100000	2083643.37614000000
B15	Wire sticking out of ground		749526.92844000000	2085367.02099000000
B16	Llinear depression		750292.88983500000	2083170.94270000000

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Annual Site Inspection Check List (see RFLMA Attachment 2, Sections 5.3.4, 5.3.6, and 5.4.3)

Date 3/16/17 Inspection Area: C1

Inspection performed by (print each name): Ryan Uzdienski, Carl Spreng, Michelle Hanson, Jeff Murl, Steve Merritt

Check all boxes that apply, put ID# on flag and place flag marker in location of observation for follow up.								
Flag ID#	Evidence of Soil Erosion or Deposition	Evidence of Cracks, Rills, Gullies	Evidence of Sink Holes or Burrows	Evidence of Depressions or Subsidence	Evidence of Institutional Control Violation[1]	Problem with signs or other physical controls[2]	Adverse biological condition	Photo(s) taken?[3]
C-1								✓
C-2								✓
C-3								✓
C-4								✓
C-5								✓
C-6								✓
C-7								✓

Notes (Reference Flag ID#): C1 - line of old fence posts > metal flush w/ground
C2 - line of old fence posts
C3 - electrical wire stuck in ground (old)
C4 - Conduit stuck in ground
C5 - Wire
C6 - Post stuck in ground + wire
C7 - more fence ~~that~~ posts in ground

[1] Indicate the RFLMA IC# (RFLMA Attachment 2, Table 1–7) for which violation is indicated.
[2] These are required to be inspected quarterly per RFLMA Attachment 2 Section 5.3.5, and completion is documented separately—documented here if problem noted during Annual Inspection.
[3] If photo taken, show location and orientation of photo on Area map.

Page 1 of ___

Annual Site Inspection Check List (see RFLMA Attachment 2, Sections 5.3.4, 5.3.6, and 5.4.3)

Date 3/16/17 Inspection Area: C2

Inspection performed by (print each name): Ryan Uzdienski, Carl Spreng, Michelle Hanson, Jeff Mull, Steve Merritt

Check all boxes that apply, put ID# on flag and place flag marker in location of observation for follow up.								
Flag ID#	Evidence of Soil Erosion or Deposition	Evidence of Cracks, Rills, Gullies	Evidence of Sink Holes or Burrows	Evidence of Depressions or Subsidence	Evidence of Institutional Control Violation[1]	Problem with signs or other physical controls[2]	Adverse biological condition	Photo(s) taken?[3]
C-8								✓
C-9								✓
C-10								✓
C-11		✓						✓
C-12		✓		✓				✓

Notes (Reference Flag ID#): C-8 - metal debris
C-9 - concrete gutter drain
C-10 - metal debris
C-11 - crack, ~45 ft long < 2 in wide
C-12 - crack, slump, highest 1 ft tall, 100 ft long, 2-3 in wide

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[1] Indicate the RFLMA IC# (RFLMA Attachment 2, Table 1–7) for which violation is indicated.
[2] These are required to be inspected quarterly per RFLMA Attachment 2 Section 5.3.5, and completion is documented separately—documented here if problem noted during Annual Inspection.
[3] If photo taken, show location and orientation of photo on Area map.

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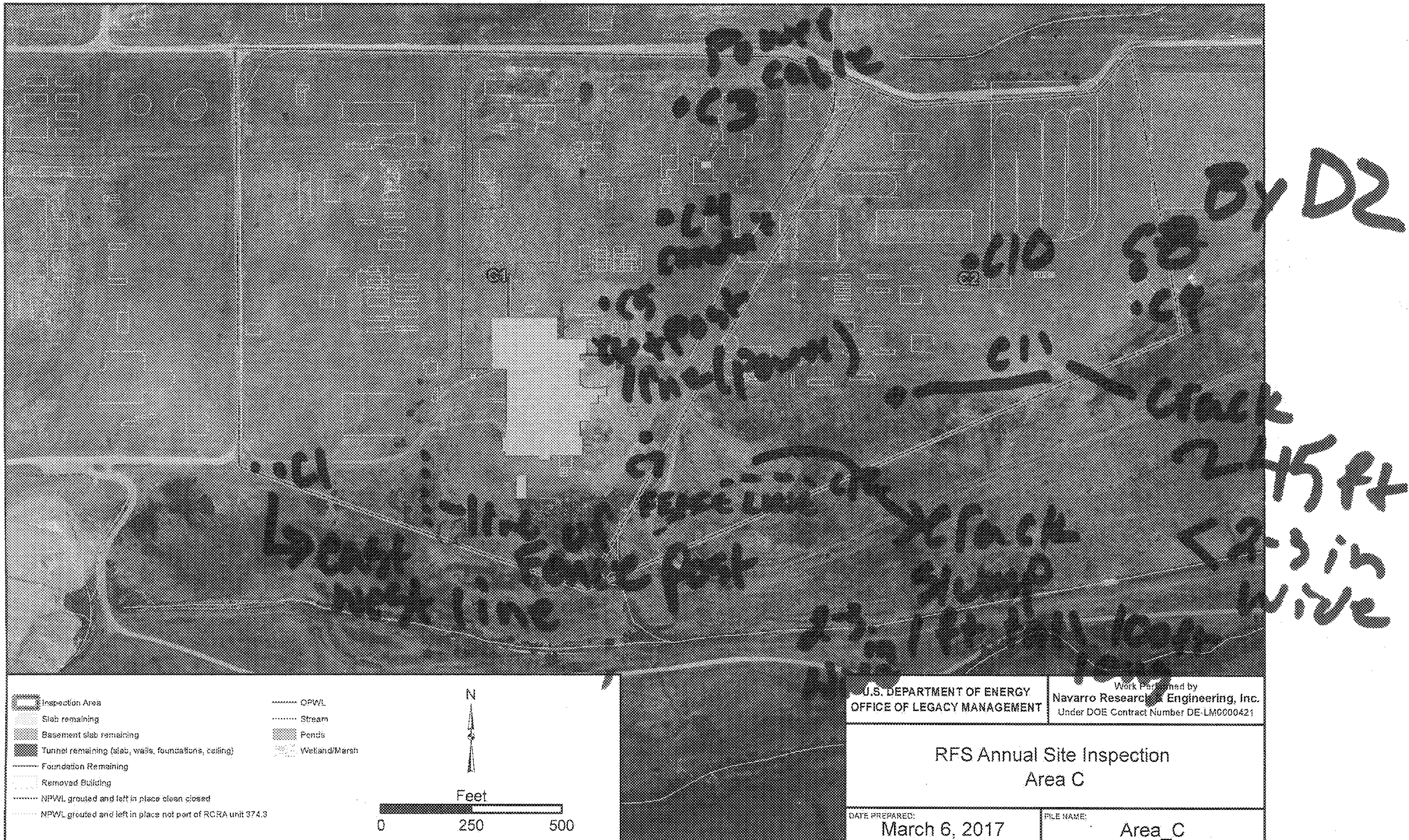

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Annual Site Inspection Check List (see RFLMA Attachment 2, Sections 5.3.4, 5.3.6, and 5.4.3)

Date ____________ Inspection Area: D

Inspection performed by (print each name): ______________________

Check all boxes that apply, put ID# on flag and place flag marker in location of observation for follow up.								
Flag ID#	Evidence of Soil Erosion or Deposition	Evidence of Cracks, Rills, Gullies	Evidence of Sink Holes or Burrows	Evidence of Depressions or Subsidence	Evidence of Institutional Control Violation[1]	Problem with signs or other physical controls[2]	Adverse biological condition	Photo(s) taken?[3]
D-1	Concrete chunk							yes
D-2	Interesting metal- 3 different kinds some electrical -3 concrete chunks							
D-3	Concrete \ lots of pieces around in the area						nearby	y
D-4	Concrete /							y
D-5	metal support bar- stuck deep							y
D-6	open culvert							
D-7	Cable- buried on 1 end - T-Bar.							

Notes (Reference Flag ID#):

[1] Indicate the RFLMA IC# (RFLMA Attachment 2, Table 1–7) for which violation is indicated.
[2] These are required to be inspected quarterly per RFLMA Attachment 2 Section 5.3.5, and completion is documented separately—documented here if problem noted during Annual Inspection.
[3] If photo taken, show location and orientation of photo on Area map.

Annual Site Inspection Check List (see RFLMA Attachment 2, Sections 5.3.4, 5.3.6, and 5.4.3)

Date ____________ Inspection Area: D

Inspection performed by (print each name): ________________________________

Check all boxes that apply, put ID# on flag and place flag marker in location of observation for follow up.

Flag ID#	Evidence of Soil Erosion or Deposition	Evidence of Cracks, Rills, Gullies	Evidence of Sink Holes or Burrows	Evidence of Depressions or Subsidence	Evidence of Institutional Control Violation[1]	Problem with signs or other physical controls[2]	Adverse biological condition	Photo(s) taken?[3]
D-8	depressions							
D-9	depressions							
D-10	metal							
D-11	erosion? ~~[illegible]~~ settleing over east trench							
D-12	cable							
D-13	depression w/ large concrete in it							

Notes (Reference Flag ID#):

[1] Indicate the RFLMA IC# (RFLMA Attachment 2, Table 1–7) for which violation is indicated.
[2] These are required to be inspected quarterly per RFLMA Attachment 2 Section 5.3.5, and completion is documented separately—documented here if problem noted during Annual Inspection.
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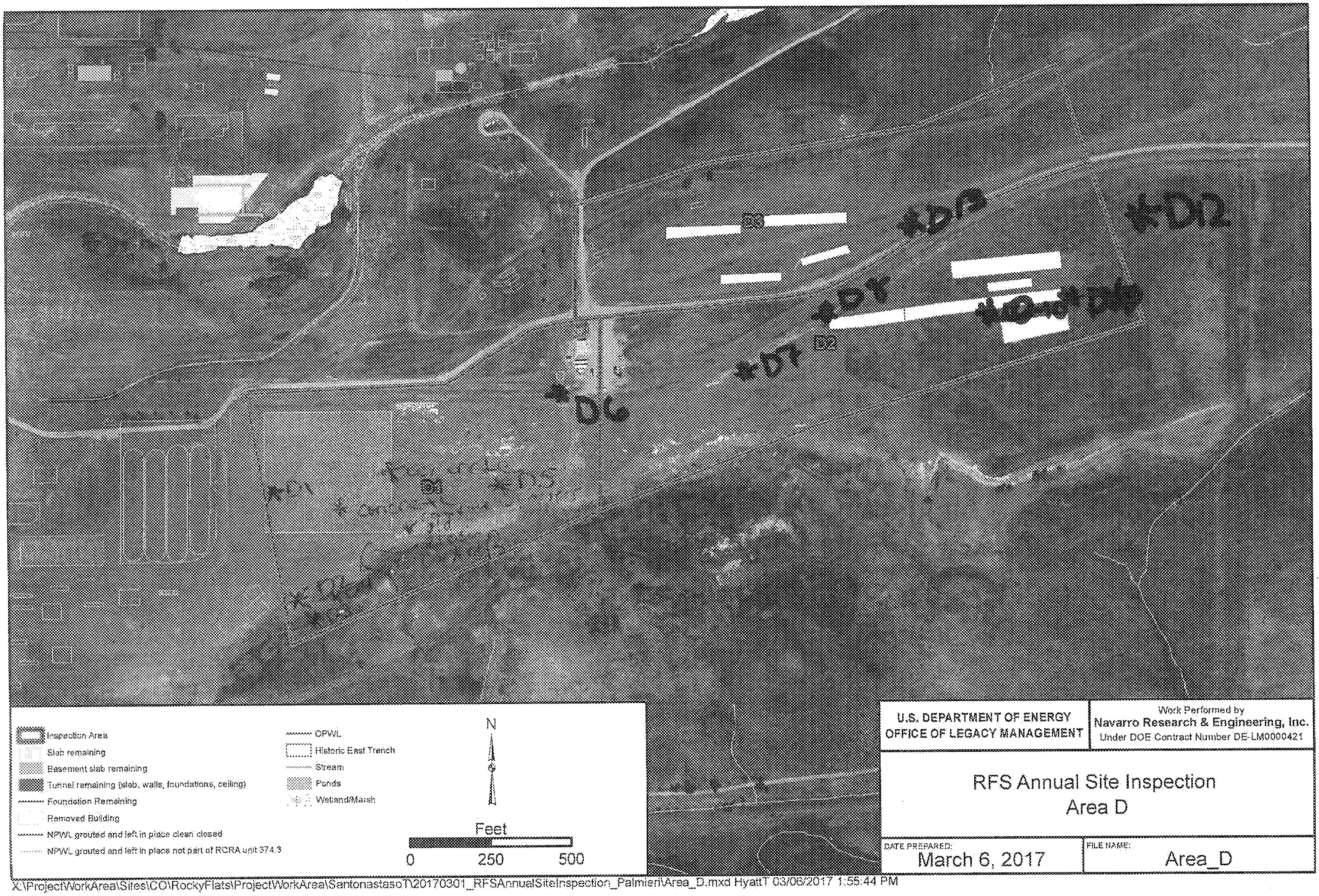
D3
D2
D1
D6
D7
D8
D9
D12
Inspection Area
Slab remaining
Basement slab remaining
Tunnel remaining (slab, walls, foundations, ceiling)
Foundation Remaining
Removed Building
NPWL grouted and left in place clean closed
NPWL grouted and left in place not part of RCRA unit 374.3
OPWL
Historic East Trench
Stream
Ponds
Wetland/Marsh
N
Feet
0
250
500
U.S. DEPARTMENT OF ENERGY
OFFICE OF LEGACY MANAGEMENT
Work Performed by
Navarro Research & Engineering, Inc.
Under DOE Contract Number DE-LM0000421
RFS Annual Site Inspection
Area D
DATE PREPARED:
March 6, 2017
FILE NAME:
Area_D
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Appendix H

ARARs

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ARAR[1]		Change	Impact to Remedy	Revision Reference	Contact Record	Effective Date
Stormwater Permit for Construction Activities	40 CFR 122.26	Issuance of the 2017 NPDES Construction General Permit (CGP) to replace 2012 CGP. (The new CGP has not been issued yet and is expected in Feb. 2017. FYR report will be updated when issued.)	None. Remedy protectiveness is not impacted because all activities subject to this ARAR, such as construction work to maintain the landfills covers and groundwater treatment systems, are conducted in accordance with the CGP substantive requirements.	Fill in with FR notice.	None	
General Permits	40 CFR 122.28	Issuance of Final 2016 NPDES Pesticide General Permit (PGP) to replace 2011 PGP.	None. Remedy protectiveness is not impacted because all activities subject to this ARAR, such as application of pesticides near onsite streams, are conducted in accordance with the PGP substantive requirements.	81 FR 75816	None	10/31/16
Permits for Dredged or Fill Material; Discharges of Dredged or Fill Material into Waters of the United States	33 CFR 323	Availability of the National Wetland Plant List, which is used to determine whether the hydrophytic vegetation parameter is met when conducting wetland determinations under the CWA.	None. Remedy protectiveness is not impacted because all activities subject to this ARAR, such as construction or maintenance at the landfills or monitoring locations, are conducted in accordance with wetlands delineation criteria.	81 FR 22580	None	05/01/16
		Notice announcing the withdrawal of the March 25, 2014 interpretive letter regarding the applicability of the exemption from permitting to discharges of dredged material associated with certain agricultural conservation practices provided under section 404(f)(1)(A) of the CWA.	None. This letter did not effect a change in the regulation, but clarified interpretation of the regulation. As such, it's withdrawal does not impact the remedy or protectiveness, since any actions taken with regard to dredged/fill material would be compliant with applicable regulations.	80 FR 6705	None	01/29/15
		Revision of definition of "Waters of the United States" in light of the U.S. Supreme Court cases.	None. This revision narrows definition of "waters of the state" and does not impact remedy protectiveness.	80 FR 37053	None	06/29/15
Colorado Basic Standards and Methodologies for Surface Water; Basic Standards Applicable to Surface Waters of the State	5 CCR 1002-31.11	Revisions and additions to basic standards for volatile organic compounds	None. Numeric standards for Carbon tetrachloride and Tetrachloroethene slightly increased from previous standards. The standard for *cis* -1,2-dichlorothene was changed to a concentration range, with the previous standard at the top of the range.	5 CCR 1002-31.51 (Statement of Basis)	2012-03	01/31/13
Classification and Numeric Standards South Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin; Classification Tables	5 CCR 1002-38.6	Revisions to site-specific standards for Big Dry Creek segments 4a, 4b, and 5 of the South Platte River Basin	None. Revisions included addition of Cr III(chronic) standard = 50 ug/L (T) for all segments with Water Supply use (5 CCR 1002-38.90(P)); addition of Cadmium, Lead, and Nickel standards for Water Supply uses of Big Dry Creek segments 2, 4a, 4b, 5, 6, and 7 (5 CCR 1002-38.90(Q)) .	5 CCR 1002-38.90 (Statement of Basis)	None	12/31/15
Colorado Noxious Weed Act	CRS 35-5.5-101 et seq.	Revisions to noxious weed lists and weed management plans.	None. Weeds are controlled in accordance with the RF integrated vegetation management approach, which is part of site maintenance activities. These amendments to the noxious weed lists and management plans do not impact remedy protectiveness.	8 CCR 1206-2	None	09/30/12; 03/30/14; 12/30/14; 12/30/15

ARAR[1]		Change	Impact to Remedy	Revision Reference	Contact Record	Effective Date
DOE Compliance with Floodplain/Wetlands Environmental Review Requirements	10 CFR 1022	Additions and modifications to Base Flood Elevations (BFEs), base flood depths, Special Flood Hazard Area (SFHA) boundaries or zone designations, or the regulatory floodway in Jefferson County, Colorado	None. These modifications are issued by FEMA and relate to flood hazard determinations; they do not alter the floodplain ARAR itself. However, FEMA is one of many resources that may be used to support flood hazard determinations required by the regulation (e.g., for new construction projects on site).	81 FR 66983	None	09/29/16
Colorado Air Permits	Not an ARAR in CAD/ROD	Air Pollutant Emissions Notice requirements	None. Since the last FYR, the passive groundwater treatments systems at two locations were reconfigured to allow treatment of groundwater from both locations at a single commercial air stripper. Because the air stipper releases VOCs to the air, the applicability of state air emissions regulations was evaluated. The calculated air emissions for the air stripper were determined to be below the regulatory threshold, thus an emissions notification to the regulator was not required, nor was an air permit.	5 CCR 1001-5 (Regulation 3, Part A II.B.3)	2014-01	

[1] From Table 21 in *Corrective Action Decision/Record of Decision for Rocky Flats Plant (USDOE)* , September 2006, unless otherwise noted.

Appendix I

Responses to Stakeholder Input on the FYR

This appendix will be provided in the final *Fourth Five-Year Review Report for the Rocky Flats Site*.

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